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EFFECTS OF A TERMINAL CONTEXT SUMMARY (TCS)
IN A MULTIMEDIA INDIVIDUALIZED INSTRUCTIONAL
APPROACH TO STATISTICS FOR
QUALITY CONTROL (QUCAST)

DISSERTATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Jeanne Louise Burson, B.S.Ed., M.S.

* * * * *

The Ohio State University
1972

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ACKNOWLEDGMENTS

The investigator wishes to express gratitude to Dr. Gregory L. Trzebiatowski, my major advisor, for his guidance and professional assistance in this investigation.

Special acknowledgment is given to Dr. Kathryn Schoen, who provided advice and encouragement throughout my entire graduate program at The Ohio State University.

Dr. James B. Gunnell and John Camiscioni were very helpful in content review of the instructional materials and with analysis and interpretation of statistical data for this study. In addition Dr. John Belland, Carol Dawson, Ohio Regional Medical Program/Computer Assisted Instruction Project, Kellogg Task Force members and especially my Instructional Programmer, Devonna Munford, gave valuable criticisms and suggestions to the investigation and made corrections of the program materials.

Heartfelt thanks are given to the doctoral candidates and all who offered constructive criticisms and served as subjects in the study.

Sincere appreciation is extended to my family and friends, who have provided personal encouragement in the completion of this graduate endeavor.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>VITA</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xii</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>The Problem</td>
<td>1</td>
</tr>
<tr>
<td>Purpose</td>
<td>7</td>
</tr>
<tr>
<td>Rationale</td>
<td>7</td>
</tr>
<tr>
<td>The Problem</td>
<td>7</td>
</tr>
<tr>
<td>Individualizing Instruction</td>
<td>12</td>
</tr>
<tr>
<td>QUCOST—Statistics for Quality Control</td>
<td>15</td>
</tr>
<tr>
<td>Instructional Media</td>
<td>16</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>22</td>
</tr>
<tr>
<td>Assumptions</td>
<td>23</td>
</tr>
<tr>
<td>Limitations and Constraints</td>
<td>24</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>25</td>
</tr>
<tr>
<td>Summary</td>
<td>30</td>
</tr>
<tr>
<td>II. REVIEW OF RELATED LITERATURE</td>
<td></td>
</tr>
<tr>
<td>Individualized Instruction in Independent Study</td>
<td>33</td>
</tr>
<tr>
<td>MISSIP</td>
<td>41</td>
</tr>
<tr>
<td>Structure</td>
<td>41</td>
</tr>
<tr>
<td>Terminal Context Summary</td>
<td>46</td>
</tr>
<tr>
<td>Multimedia</td>
<td>48</td>
</tr>
<tr>
<td>Programmed Instruction Booklet</td>
<td></td>
</tr>
<tr>
<td>(Scrambled Book)</td>
<td>49</td>
</tr>
<tr>
<td>Computer Assisted Instruction (CAI)</td>
<td>54</td>
</tr>
<tr>
<td>Criterion Referenced Tests</td>
<td>60</td>
</tr>
<tr>
<td>Performance Unit (PU)</td>
<td>61</td>
</tr>
<tr>
<td>Program Effectiveness</td>
<td>63</td>
</tr>
<tr>
<td>Summary</td>
<td>67</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (continued)

Chapter

III. METHODOLOGY ........................................... 69

| Research Study ............................................. 70 |
| Hypothesis .................................................. 70 |
| Experimental Design and Procedures .................. 71 |
| Statistical Procedures ................................. 74 |
| Program Development ....................................... 76 |
| Task Detailing ............................................... 77 |
| Learning Outcomes .......................................... 78 |
| Terminal Context Summary .................................. 80 |
| Program Material: QUCOST .................................. 85 |
| Criterion Referenced Tests ............................... 85 |
| Specific Learning Activity Tapes (SLAT) .............. 92 |
| Learning Outcome Tutorial Evaluation .................. 93 |
| Segments (LOTES) ............................................. 95 |
| LOTES: CAI ................................................... 96 |
| LOTES: PIB .................................................... 100 |
| MISSIP Evaluation .......................................... 113 |
| Computer Printout and Response Sheet .................. 115 |
| The Opinionnaire ............................................ 116 |
| Summary ...................................................... 117 |

IV. ANALYSIS OF THE DATA .................................. 120

| Research Study ............................................. 120 |
| Statistical Assumptions ................................. 120 |
| Comparison of Research Groups ......................... 126 |
| Interim MISSIP Evaluation ............................... 131 |
| By Group Assessment: TCS/NTCS ......................... 131 |
| Performance on Criterion Tests ......................... 132 |
| Performance in LOTES ...................................... 135 |
| Levels of Learning: Achievement ....................... 135 |
| By Individual Assessment .................................. 138 |
| Performance on Criterion Tests/LOTES ................. 138 |
| By Performance: Subgroups ................................ 144 |
| Time as a Variable ......................................... 146 |
| Opinionnaire: Response Data ............................. 153 |

V. SUMMARY CONCLUSIONS AND RECOMMENDATIONS .......... 165
 TABLE OF CONTENTS (continued)  

Page  

Chapter  

Summary ........................................ 165  
Problem-Purpose .................................. 165  
The Development Phase ............................ 167  
The Experimental Phase ........................... 168  
The Tryout-Revision Phase ........................ 170  
Effects of a Terminal Context Summary .......... 170  
MISSIP Evaluation ................................... 172  
Achievement ........................................ 172  
Time ............................................... 174  
Opinionnaire ....................................... 175  
Significance of the Study ........................... 176  
Conclusions .......................................... 177  
Recommendations ..................................... 181  

APPENDIX  

A. Ohio State Regional Medical Program  
   Computer Assisted Instruction  
   Project Survey Report .......................... 183  
B. Ohio Regional Medical Program/  
   Computer Assisted Instruction  
   Network .......................................... 188  
C. Computer Assisted Instruction:  
   Modes of Instruction ............................ 194  
D. Computer Assisted Instruction in  
   Independent Study ................................ 200  
E. Participant Instructions:  
   Research Study ................................... 214  
F. Terminal Context Summary ...................... 224  
SELECTED BIBLIOGRAPHY ............................ 231
LIST OF TABLES

1  Panel Response to QUCOST Objective Validation Criteria ......................... 84

2  Criterion Item Data Presenting Assigned Related Learning Outcomes and Level of Learning ......................................... 89

3  Table 2 Data Reorganized to Demonstrate Equated Construction Criterion 1 ($C_1$) and Criterion 2 ($C_2$) ........................................ 90

4  Tables 2 and 3 Data Reorganized by Subject Area and Level of Learning to Demonstrate Equated Form -- $C_1$ and $C_2$ ........................................ 91

5  Group Means ($\bar{X}$) Standard Deviations (s) and Mean Performance Units (PU) for Statistics and No-Statistics Background Groups on the Entry ($C_1$) and Terminal ($C_2$) Tests ........................................ 122

6  Comparison Data for the Terminal Context Summary (TCS) and No-Terminal Context Summary (NTCS) Groups on the Entry ($C_1$) and Terminal ($C_2$) Criterion Referenced Tests ........................................ 123

7  Descriptive Statistics of Performance Units by Group -- TCS and NTCS ........................................ 125

8  Means, Standard Deviations, and Performance Units of Objective Achievement Percentage on $C_1$ and $C_2$ for the TCS and NTCS Groups ........................................ 127

9  t Test for Significance Between the Mean Performance Units of the TCS and NTCS Groups ........................................ 129
# LIST OF TABLES (continued)

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Mann-Whitney U Test for Significance between the Performance Units of the TCS and NTCS Groups</td>
<td>130</td>
</tr>
<tr>
<td>11</td>
<td>Group Means and Standard Deviations of Objective Achievement Percentage for the TCS -- NTCS Groups in Four Subject Areas of $C_1$ and $C_2$</td>
<td>133</td>
</tr>
<tr>
<td>12</td>
<td>Performance Unit Percentage Means for the TCS and NTCS Groups in Four Subject Areas of $C_1$ and $C_2$</td>
<td>134</td>
</tr>
<tr>
<td>13</td>
<td>Mean Objective Achievement Percentages for the TCS and NTCS Groups Without and Following Coaching in Eight Tutorial-Evaluation Segments (LOTES)</td>
<td>136</td>
</tr>
<tr>
<td>14</td>
<td>Means, Standard Deviations and Mean Performance Units of Question Level Achievement Percentages for TCS and NTCS Groups on $C_1$ and $C_2$</td>
<td>137</td>
</tr>
<tr>
<td>15</td>
<td>Learner Objective Achievement Percentages and Approximate PU on $C_1$ and $C_2$ and Objective Achievement Percentages in the Quality Control Segments of the LOTES for TCS and NTCS Groups</td>
<td>139</td>
</tr>
<tr>
<td>16</td>
<td>Learner Objective Achievement Percentages and Approximate PU on $C_1$ and $C_2$ and Objective Achievement Percentages in the Statistical Terms Segments of the LOTES for TCS and NTCS Groups</td>
<td>141</td>
</tr>
<tr>
<td>17</td>
<td>Learner Objective Achievement Percentages and Approximate PU on $C_1$ and $C_2$ and Objective Achievement Percentages in the Central Tendency Segments of the LOTES for TCS and NTCS Groups</td>
<td>142</td>
</tr>
</tbody>
</table>
LIST OF TABLES (continued)

18 Learner Objective Achievement Percentages and Approximate PU on $C_1$ and $C_2$ and Objective Achievement Percentages in the Dispersion Segments of the LOTES for TCS and NTCS Groups ........................................ 143

19 Performance Units by Entry Objective Achievement and Professional and/or Educational Background Groupings ........................................ 145

20 Terminal PUs, Interaction Time and Maximum Gain Per Hour Ratios in the Self-Evaluation Segments ........................................ 151

21 TCS and NTCS Group and Total Means and Medians Maximum Gain/Hr. Ratios ........................................ 152

22 Mean Interaction Time (Minutes) for TCS and NTCS Groups in the Eight Tutorial-Evaluation (LOTES) and Learning Activity Segments (SLATS) ........................................ 154

23 Mean PU on $C_2$, Mean Hours in LOTES and Mean Maximum Gain/Hr. for TCS and NTCS in the Four Subject Areas ........................................ 155
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Task Detailing Sheet</td>
<td>78</td>
</tr>
<tr>
<td>2</td>
<td>CAI--Question Sequence: Part I</td>
<td>98</td>
</tr>
<tr>
<td>3</td>
<td>Sequence: Part II</td>
<td>99</td>
</tr>
<tr>
<td>4-12</td>
<td>PIB-Sequence: Segment 4.0 (Pages 11, 15-22)</td>
<td>102-110</td>
</tr>
<tr>
<td>13</td>
<td>Individual PU Over Hours Interaction in 8 Segments of QUCOST</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>with Mean and Median Maximums Achievement/Interaction Line</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Individual Total Objective Achievement Percentages on C₁ and C₂ Over</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>Interaction Hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with Maximum Gain Per Hour Noted (TCS Group)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Individual Total Objective Achievement Percentages on C₁ and C₂ Over</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Interaction Hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with Maximum Gain Per Hour Noted (NTCS Groups)</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

The Problem

The health related professions are coming of age and change is rapid. The learning experience of students and practitioners should reflect this change. At the Fourth (1968) Rochester Conference on Self-Instruction in Medical Education, the allied health education group raised questions related to the significant differences in the student's background.¹ The instructional media and materials experts for allied health subjects, who must cope with this problem, have also voiced their concern. The expressed need was for a wide variety of short specific units of instructional material that could be fitted into quite different curricular patterns at different levels of entry.

Qualified health professionals of the future might

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well be described as self-motivated learners—motivated from without and within—with the capabilities to sift through the irrelevancies and logically determine the validity of the mass amount of technical material that is needed to achieve a degree of expertness.

Medical Technology is no exception. According to the 1971 listing of the 45 American Medical Association (AMA) Approved Schools of Medical Technology in Ohio, 38% of the schools have affiliation with two academic institutions, 24% just one, 13% have four, 9% have three and 6.5% have none. The remaining schools have affiliation with 5 to 10 academic institutions. One might tend to agree, on the basis of this data alone, that 76% of the schools must face the problem of divergent backgrounds with students entering as one group.

The pre-clinical admission requirements in existence today, to an AMA Approved School of Medical Technology, became effective in 1962. Requirements included in the guidelines are: (1) 16 semester (24 quarter) hours of general chemistry (a strong recommendation for quantitative analysis), (2) 16 semester (24 quarter) hours of biological science selected from several alternatives—bacteriology recommended; and (3) 1 semester or quarter hour of college

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\(^2\)A publication of the Ohio Society of Pathologists.
mathematics. The remaining hours of study, to meet the total requirements, may be selected from several suggested or equivalent courses, with a recommendation that one be physics.\(^3\)

This wide latitude of prerequisites allows the course of study to be specified by each academic institution—presenting a kaleidoscopic background in prospective clinical students. Some schools of medical technology, therefore, are confronted with the problem of instructing and evaluating students with this heterogenic history. Of necessity then, the design for clinical instruction should meet the needs of the students who have met the varied requirements of the institutions.

Israel Light eluded to the academic institutions and their unjustified academic requirements when he stated:

\[
\begin{align*}
\text{Now, another and related problem} \\
\text{deals with the drive for academic respectability and visibility, on} \\
\text{the assumption that education is} \\
\text{somehow related to intelligence} \\
\text{and competence.} \\
\text{Educational Establishments train} \\
\text{people for the piece of paper} \\
\text{rather than for competence on} \\
\text{the job.} \\
\text{We all know of too many instances} \\
\text{in which there is no positive relationship between possession of} \\
\text{paper and competent job performance.}^{4}
\end{align*}
\]

---


\(^4\)Israel Light, "Growth and Development of New Allied
Moreover, he implied that health personnel education will have to be based on well stated job descriptions and analyses which will tend to: 1) educate more competent people and give some meaning and value to the degree received; 2) give more social order and happiness to the holder; 3) specify in terms of specific behaviors the knowledge, ideals, technical expertise and skills that identify the professional medical technologist; and 4) provide a means to effective instruction for job competency by stating specifically what the practitioner is suppose to do, under what circumstances he will do it and what level of accuracy is demanded.\textsuperscript{5}

The need for better trained and more highly skilled clinical laboratory personnel will have to be met as the demand for comprehensive health care broadens and is accepted. The specifics of medical technology will need to be up-dated constantly so that the practitioner of tomorrow is capable of advancing and up-dating himself as needed. Producing more of the same type of programs will not suffice. Sophisticated methods of instruction will have to be employed not only to meet the needs of the ever changing

\textsuperscript{5}Light, "Growth and Development," pp. 77-78.

\textsuperscript{5}Light, "Growth and Development," pp. 77-78.
medical technology profession but to reach those, who for various reasons cannot return to the classroom for an extended program of study.

According to Manning, Abrahamson and Dennis,

It is clear that as we develop greater ability and understanding in continuing education..................
..............................
it will become necessary to develop more effective and efficient means of teaching knowledge. While knowledge itself may give no assurance that the care of patients will be improved, knowledge is the first step upon which both ability and motivation to use information rests.6

Two particular program development projects were proposed at the Fourth Rochester Conference in 1968. The first suggested remedial programs designed to make up deficiencies in basic college program prerequisites. The second proposal was for "the prompt development of audio-visual self-instructional units in a variety of techniques and procedures that are currently taught in almost all of the allied health courses...."7


Recognizing these concerns and within the guidelines cited above, the present study was proposed. Instructional programs are usually devised in the hope of optimizing learning—but how? Experimental work, while quite extensive, has not yielded much in the way of unequivocal results. Indeed some instructional methods work better than others. Some methods work well for some people but not for others. A theory of instruction should concern itself with the relationship between how things are presented and how they are learned. Briggs has indicated that although almost all theoretical positions contain some reason for placing importance upon the sequence of instruction, researchers have found it necessary to look outside learning theory to find conceptualizations for some problems in instructional design.8

However, one question seems to lack extensive experimentation:

Does the degree of explicitness with which the objectives are specified prior to a learning experience influence terminal objective achievement? In an attempt to answer this question it was, therefore, proposed that a terminal context summary (TCS) would facilitate the achievement of

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terminal objectives, regardless of the instructional situation. The instructional situations in question utilized self-evaluation-tutorial materials programmed for computer assisted instruction (CAI) or in a programmed instruction booklet (PIB).

A terminal context summary is an elaboration of the terminal objectives. Its purpose is to give meaning and/or reality to the expected learning outcomes and to allow the learner to organize and/or structure existing knowledge into the context of acceptable terminal performance.

Purpose

The major purposes of the study were to develop a multimedia individualized specific subject instructional program to provide an effective learning experience for health related personnel with divergent cognitive backgrounds; to measure, by a modified gain score, the effects of a comprehensive terminal context summary, given prior to the instructional sequence; and to assess the effectiveness of the program in a quasi controlled tryout phase, making revisions as necessary.

Rationale

The Problem

Health Related personnel must be capable of serving
the interest of the consumer. The need for planned and orderly educative experiences, designed to achieve effective objectives, is seldom denied. But just what is the product of the educational process to be: An 8:00 A.M. - 5:00 P.M. practitioner? An expert doing his own thing? A walking textbook? Or should the product be an individual with potential and capabilities for continued growth—an integrated person whose expertise is in the deliverance of the best health care possible? A person who has not been actively engaged in the practice of the profession faces the possible lack of present day skills. Will available instructional programs or the "crash-programs initiated to answer the needs of the health care system produce the needed product now and in the foreseeable future?

Yeazell stated, "The more you know about a field the more sensitive you are to it...sensitive to discrepancies, discontinuities and incongruities in the data with which he works....It is this sensitivity to problems that separates the outstanding worker from the merely good one."9

The hospitals of today tend to adhere to a piecemeal construction of programs instead of concentrating on the proper utilization of all the educational resources available. Many also fail to consider that the learner is an

---

individual with his own set of emotional, mental and practical experiences. Moreover, if the educational process is to "catch-up and keep-up" with medical advances, an organized and coordinated continuing education program will have to be the result of a collaborative and systematic approach in confronting the problem. No one method is a means in itself.

The responsibility for providing the best learning situation necessitates finding out just where the learner is on the so-called "lattice" of learning. Instructional efforts should not be duplicated. Moreover, gaps in the learning process should be identified before it is too late for restoration. The cumulative effect of non-learning could create a major cognitive relapse if allowed to continue. Evaluation is conducive to learning when it provides for and encourages self-evaluation.

Nevertheless, in order to combine the practical with the theoretical, the learning experience must motivate the learner to maximize his critical thinking ability. It should provide the means by which one can discuss topics with other health related professionals and can acquire an understanding for the other person's point of view. Relevant learning experiences should be provided for the generalist, specialist, administrator and educator. This might be better done, according to Levine, if the essentials for schools were "stated in terms of what a person should be
able to do, rather than in terms of the hours and learning required.\textsuperscript{10}

The challenges and conflicts involved in the transfer of knowledge, change and growth of the individual need to be understood in order to provide quality instruction with motivation for learning. According to Ruth French, "teaching that helps students find a framework within which to fit new facts is likely to be much more effective than teaching that simply communicates masses of material in which the student can see no organization."\textsuperscript{11}

Another viewpoint on the same subject was expressed by Gagne' when he said, "One has only to attempt to acquire new knowledge by reading in an unfamiliar field to recognize at once the necessity for learning the concept of that field before further learning can transpire."\textsuperscript{12}

The same concept was more definitely stated by two questions posed by Miles and Robinson and studied by Magdraz.


The second question suggested the research variable considered in this study.

Does revealing objectives to students facilitate achievement of the objectives?

Does the degree of explicitness with which objectives are specified by teachers prior to instruction influence the quality of cognitive skills or attitudes achieved by their students?13

Magdarz concluded in the article, "Pretesting and Branching," that:

Many of our current branching-type programmed instruction courses could be made more efficient and less frustrating to the students who have some prior experience if the summary presentation method of pretesting were employed."14

The local, state and national professional societies, hospitals, colleges, universities, Regional Medical Programs, commercial companies and the "coffee break" are answering the cry for learning experiences that deal with the educational needs of the individual. The learning experiences are flexible but many times are inaccessible, lack


consistency with individual needs and fail to motivate the learner to maximize critical thinking. Therefore, new methods of presenting learning activities need to be investigated. Suggestions have been made that knowing, in detail, what a health professional does in the day to day routine will provide a framework for the development of instructional materials. Then, within this framework, the materials might be sequenced and presented in a manner suitable to the specific learning patterns of the various individuals. Accepting the need of the professions and recognizing the learner as an individual, one instructional problem is the construction of learning activities that facilitate learning. A second problem is "how".

Individualizing Instruction

"Fitting then the best academic learning situation to the individual seems to be the name of the game in the seventies." This statement was made by William McKeefery after observing that

the purpose of all this activity is to lead the learner to a given outcome in the most effective fashion. Review on ways to do this now show that some methods work better than others. It also shows that people vary as
to which method they prefer.\textsuperscript{15}

There appeared to be two approaches to the one presentation problem. Magdraz's model presented the comprehensive context summary prior to the pretest. The present research proposed to present the summary following the entry criterion test. The test included, for all subjects, a concise statement of the terminal objectives. It was proposed that the summary would facilitate achievement of the program objectives.

Implementation of individualized instruction, according to Burns, "is enhanced if the program is sub-divided into small manageable parts and a systematic method for dealing with the parts is established."\textsuperscript{16} He suggested providing the learning activities in the form of modules—short (1-3 hrs.) organized sequences. Past experiences of this researcher supported selection of this form for this study.

Since a module is a planned series of learning activities designed to help the learner accomplish specified learning outcomes, i.e. objectives, there are numerous ways in which such programs can be utilized. According to


Klingstedt, a whole course of instruction can be completed through the use of modules. Modules can be enriched segments that present course content; they are designed and developed with the learner in mind; and appear to offer an alternative to the "traditional 'textbook' approach to instruction."17

Modules can await the learner; he need not "meet the class" at the specified time. Since this type of instruction is individualized, the learner can maintain a desirable pace and is allowed the opportunity to browse other sources for information. When designed in various media, the modules offer the learner a varied "diet" toward achievement.

Another purpose for the modular or segment approach to curriculum design was emphasized by Helen Crowley, American Society of Medical Technologists (ASMT) Chairman of the medical technology representatives to the Kellogg Project Task Force (University of Illinois Medical Center), in a 1971 Activities Report to the ASMT President.

It should be emphasized that the units of instruction do not encompass complete courses but are instead, small segments of material which might be incorporated into a particular course. .................
As we gain experience in designing and building units of

instruction within our particular course segment, we will be able to expand our individual efforts to cover larger segments. Perhaps the greatest problem we all face is the thought of the tremendous effort it will take to organize a whole course structure in the so-called educational format. This will force us to truly evaluate our curricula and to take a much closer look at expected learning outcomes for the various levels of technology education and training.\textsuperscript{18}

Independent study, individualized learning and the modular approach have become topics of investigation in considering the learner as an individual—not as a member of a group. Studies have been made to investigate sequence, media, presentation and achievement. By breaking a program into parts, the parts can be organized, by the learner as well as the instructor, into a multimedia format designed for objective achievement. Pace, in addition to content, can be self-regulated by the learner, thereby optimizing the likelihood of his attainment of specified learning outcomes.

\textbf{QUCOST—Statistics for Quality Control}

With these ideas in mind, it was felt that attention

\textsuperscript{18}The Task Force is one effort of the teacher training project funded by the Kellogg Foundation. This writer was a participant of that Task Force.
should be directed to the development of a short specific instructional program, vis.—Statistics for Quality Control (QUCOST).

The concept of quality control is not new. Medical technologists are confronted with its application upon entering clinical instruction. Persons working in clinical laboratories today must know basic statistics in order to understand the concepts of quality control. A search of the literature revealed that the individualized instructional materials, (other than commercial product manuals) that deal with basic statistics, contain many statistical concepts not directly associated with quality control. Clinical experience and personal observation suggested that when confronted with this in-depth presentation, many individuals withdrew from active participation in learning experiences with statistics. This evidence and the findings of a Needs Survey, conducted by the Ohio State Regional Medical Program Computer Assisted Instruction Study (OSRMP-CAI) in 1971, prompted the selection of QUCOST as the vehicle for the proposed study.\(^{19}\)

**Instructional Media**

A major problem remaining to be considered was the

\(^{19}\)School of Medical Technology educational coordinators, chief technologists and pathologists in 12 hospitals were interviewed. A report of that survey is given in Appendix A.
particular method by which individualization of instruction might be realized and moreover, utilized in an effective manner.

Different kinds of learning may require many different types of external conditions of learning. Briggs pointed out:

Multimedia are needed primarily to provide the range of displays needed, and to provide feedback and evaluation of responses. In total, the media are the means for providing stimuli, whether the stimuli are used to motivate, to direct attention, to set a goal, to give a prompt, to evaluate, to guide thinking, to evoke a response or to test for transfer. 20

Medical technology, along with other professions, has been speaking out for a long time about the lack of a method by which one can continuously evaluate the progress of a student—a learning experience that includes a method to measure understanding, the thinking process, the order of response, areas of weakness and strength, time for responses and also will relate to some degree the value and worth of the instruction.

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One innovative method, which relates to these views, seemed to have eluded effective utilization by the health related professions. This was Computer-assisted instruction-Tutorial evaluation system (CAI-TES). CAI-TES emphasizes the active involvement of the individual in the learning situation plus immediate, individual and appropriate responses provided the user by the computer system. Both instructional material and logic are stored in computer memory.

Direct instructional applications of the computers have had mixed success. Although the simple drill application for teaching arithmetic and spelling have been very effective, CAI is still in its infancy and must yet prove its worth before wide spread usage as a tool for instruction is accepted. Its great worth should lie in its ability to generate complex skills involving chains of verbal discourse and problem solving not easily accomplished by simple "book instruction".

During the past decade, numerous groups at universities, non-profit institutes, and industrial corporations have begun to explore the possibility of using the computer for instruction. More people demand continued individualized education tailored to their needs and motivations. Therefore, qualified educators have turned to methods that meet these needs. Under mixed reactions many programs have been instigated to evaluate the role of CAI.
in this connection.\textsuperscript{21}

Empirical data indicated a need for more flexible CAI. Results showed that CAI has promise as part of a total program that complements other learning resources. Bowden suggested that CAI has found a place in pathology instruction—both as a dialogue program and in the programmed clinicopathological conference. He concluded that it is, therefore, reasonable to suggest that some areas of medicine might benefit from this form of automation.\textsuperscript{22}

The parameters of the Ohio State Regional Medical-Computer-Assisted Instruction Network (OSRMP-CAI) were major constraints in utilization of CAI-TES in this study. This network is somewhat localized—with 15 hospital terminals within the radius of 150 miles of Columbus, Ohio.\textsuperscript{23} In order to provide for generalization of the study beyond the local scene, an alternative mode of presentation was developed—a programmed instruction booklet (PIB).


\textsuperscript{23}The OSRMP-CAI Network is explained in Appendix B.
Identical content, illustrations and whenever possible identical phraseology were incorporated into the PIB. The construction of the PIB was a major problem. A practical solution indicated that the "scrambled" book format might allow flexible branching, required in a prescriptive or diagnostic type program. The prescriptive process allowed differential assessment and learner decision points.

According to Reynolds, "CAI permits the researcher to study quite complex learning variables in a reasonably pure atmosphere not unlike a lab and at the same time as a reasonable realistic learning situation." This is not possible with PIB. Therefore, recognition of these variables were accounted for in the experimental design--stratification on the instructional situations.

The selected instructional media might be utilized at a location and time convenient to the learner. He need not travel from place to place in order to participate in learning activities. Rockhart, Scott and Zannetos further suggested that computer assisted instruction offered a new approach at the college level by:

1) Allowing the student to utilize his own particular background and to learn in his own way at

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his own particular rate of speed;

2) Reducing the burden upon the instructor of simple repetitive material time after time;

3) Allowing the integration of instructional material within and across functional fields;

4) Providing an experimental setting for research in the learning process.25

This study was, therefore, designed as one approach, with multi-instructional facets, to the development of an individualized program for basic statistics of quality control in the clinical laboratory. Research was proposed to study the effects of the presentation of a terminal context summary following the entry criterion and prior to the learning activities. Considering the learner as an individual, the learning activities were designed in various media: audio tapes for presentation of the learning activities and a scrambled booklet and computer assisted instruction for the tutorial-self evaluation segments. Slides were utilized throughout the program for discussion, demonstration and evaluation. This multimedia approach provided a range of activities adaptable to the individual student or practitioner, the time for involvement and the place.

A pretest-post-test design allowed for random selection of volunteer health professionals for two groups and exposure of one group to the independent variables—the comprehensive objective summary. Maximum gain achievement was proposed as the dependent variable in testing the significant difference in the achievement performance of the groups.

Interim evaluation of the effectiveness of the program was based on gains, objective achievement, time in relation to achievement and participant opinion. Revisions were made in the instructional materials following an analysis of the data.

Significance of the Study

The educational significance of this study was to provide, through interim evaluation, an individualized instructional program to augment presently available materials. The program might serve as guidelines for additional program development, as well as learning experience for those interested in basic statistics utilized in quality control. As mentioned in the previous section, the proposed research studied the cognitive effects of reviewing a comprehensive summary of specified learning outcomes prior to the learning activities. Studies are now in progress that deal with the significance of presenting the terminal objectives but only the studies of Magdraz and that of C'de BaCa and
Chadwick were found to consider presentation of an objective summary prior to instruction.\(^{26}\)

The study was designed to measure not only the cognitive effect of the summary as presented prior to entry into the instructional program but also to report the efficiency of this sequence.

Although not a direct concern of this study, the data might offer some information concerning the significance, if any, of the summary on question level achievement, objective achievement by participants with various levels of educational, professional and/or statistical backgrounds and entry objective achievement.

This study should also suggest procedures and provide instruments for validation of program objectives based on a task detailing.

The selected booklet design for the tutorial self-evaluation segments might serve as a model for the development of other individualized programs requiring the branching and diagnostic capabilities of computer assisted instruction.

Assumptions

1) The experimental subjects were volunteers;


2) Honesty and compliance with procedural instructions were practiced by all subjects;

3) Attitudes toward the instructional situation were favorable in the sense that the subjects were volunteers;

4) Machine malfunctions did not occur to such a magnitude that negated the findings of the study;

5) The learners had some knowledge of the application of mathematical functions;

6) The answers obtained from the Programmed Instruction Booklet reflected the actual progress of the participants through the program;

7) The time recorded to terminal criterion was an estimation and treated accordingly.

**Limitations and Constraints**

Some general limitations and constraints of this study were:

1) The scarcity of directly related research studies;

2) The sample frame consisted of volunteers;

3) Volunteer participation did not imply interest or motivation in statistics for quality control. In most instances participation was for review of the program and not in reality as a learning situation;

4) Insufficient funds for mass professional production of the slides and cassettes utilized in the program might
have obscured effectiveness of the media;

5) The quasi-control research situation violated concepts of independent study by restricting the use of outside resource materials and personal tutorage;

6) Tryout data, used as an interim validation of the instructional program were also used to attest to the effects of the terminal context summary;

7) The study had no provision to measure retention. In this quasi independent study situation the exact elapsed time from termination of the program to measurement by criterion 2 was not controlled. The only restraint made was that the total interaction time should not exceed two weeks.

8) Limitations are inherent in all statistical methods; therefore, limitations may exist in the statistical method employed in this study.

**Definition of Terms**

To facilitate understanding of how certain terms and initials or acronyms are used in the study, a list of definitions is given before summaring the introduction.

**Facilitate**—Make easier or less difficult and assist the progress of the participant.

**Effects**—Results. The primary interests are in a statistical difference in objective achievement and observable variation in recorded interaction time and
individual objective achievement in this program.

Terminal Context Summary (TCS)—A brief but comprehensive discussion of the minimal acceptable performance that tends to give purpose and reality to the program objectives.

MISSIP--Multimedia individualized specific subject instructional program.

Multimedia--More than two methods (modes) of learning materials.

Individualized instruction--Learning activities designed, as near as possible, in terms of the learners needs and characteristics (assumed) as well as his present cognitive behaviors and objectives.

Specific subject--Limited to one or a few aspects of a broader area of educational concern.

Program--Organized learning sequences constructed in accordance with task detailing or description.

Task detailing--Identifying learning outcomes required by an individual in the day to day performance of a specific task.

Quality control (QC)--The collection and summarization of test data as a means for detecting systematic variation from the precision expected in a continuous process.

QUCOST--Statistics for quality control--a MISSIP dealing primarily with measures of central tendency and dispersion.
Pre-entry instruction—Learning activities required by the learner to attain achievement of specific learning outcomes i.e. calculation of square root and basic functions of mathematics.

Developmental instruction—Adjunct learning activities that elaborate on related topics to bring about achievement at or beyond the minimum accepted performance.

Adjunct—Complementary to but not necessarily part of.

General learning outcomes (GLO)—Expected terminal achievement and/or performance—end product.

Specific learning outcomes (SLO)—Interim achievement and/or performance that enables the learner to attain the GLO.

Learning activities (LA)—Learner experiences based on the interaction with subject matter and instructional methods and materials.

Effectiveness—A descriptive and evaluative combination of learner achievement, learning time and program appropriateness under specified conditions.

Appropriateness—The extent to which the program content is in agreement with the learning outcomes and is capable of teaching what it intended to teach.

Module—A short (less than 3 hours) organized learning sequence that develops one specified general learning outcome.

Efficiency—The degree of attainment in terms of the use of learner time and other resources.
**Instructional situation**—Computer assisted instruction—tutorial evaluation system or programmed instruction booklet.

**CAI**—Computer assisted instruction—a man-machine instructional interaction, in which the instruction is provided by the computer system, for the purpose of learning and retention of that learning.

**TES**—Tutorial evaluation system—Self-evaluation with tutorial feedback consisting of stimuli, learner response and interaction with immediate information and/or reinforcement and continued individual evaluation.

**PIB**—Programmed instruction booklet—printed instruction—evaluation material, in the form of a scrambled text, that expects responses on the part of the learner.

Scrambled book—A tutorial-self evaluation booklet that allows the learner to progress through the programmed sequences according to his responses, anticipated or unanticipated. The book is not read in page sequence nor is the sequence the same for each learner.

**SLAT**—Specific Learning Activity Tape.

**LOTES**—Learning Outcome Tutorial Evaluation Segment.

**DIT**—Developmental instruction tape.

**Ohio State Regional Medical Program—CAI Network (OSRMP—CAI)**—15 IBM 1050 teletypewriter terminals in community hospitals connected by phone wires to the Ohio State
University Medical Center IBM 360-50 computer system
(COMPUTER LANGUAGE-COURSEWRITER III).

**Performance Unit (PU)**—A modified gain score:

\[
\frac{\% \text{ of objective achievement on } C_1 - \% \text{ on } C_2}{100\% - \% \text{ of achievement on } C_1}
\]

**Criterion 1 (C₁)**—A criterion referenced test for entry assessment.

**Criterion 2 (C₂)**—A criterion referenced test for terminal assessment of learner achievement.

**Question style**—True-false, matching, ranking, multiple choice, analogies and constructed response type questions.

**Question level (Level of Learning)**—A subjective identification of questions according to cognitive levels of learning:

- **Level I** Knowledge—recall
- **Level II** Interpretation—comprehension
- **Level III** Problem solving—application
- **Level IV** Analysis—synthesis

**Tryout-phase**—The interim program evaluation period in which data are generated for the purposes of determining the instructional effectiveness and program revision necessary prior to field testing.
Summary

Medical technology requires that the practitioner retain a "store house" of information. Effective recall is essential and once recalled there must be proper synthesis and application of this knowledge. Moreover, study habits and skills must be established, reestablished and sharpened. Education is truly a continuum and it requires efficient utilization of facilities, personnel and faculty to be successful.

The learning experiences should be flexible—in order to facilitate progress through a program and promote better understanding. The material must be verbally adequate and designed to teach the objectives and promote interaction with the learner. Feedback needs to be understandable in order to lend to the total experience.

The health professional, in order to function at maximum, has found it necessary to continue year after year to add to his knowledge and insight. However, the work schedule of the professional makes it almost impossible to attend programs presented at scattered sites throughout the country. Therefore, the expressed need is for accessible, relevant and short specific programs that deal with the important, reinforcing and innovative principles that confront the individual.

Moreover, the mode of learning should be adaptable to
the personalities and past experiences of individuals, who vary in the rate, comprehension and retention of what is learned. A method of instruction, therefore, should relate to the needs of the individual, so that what needs to be learned can be learned when needed and can instill within the individual the ability to apply this knowledge in reality.

Many of the expressed needs suggested individualized—even independent study—programs. Individualized-independent study cannot replace actual clinical laboratory instruction but coupled with other media this instructional combination can offer much as a learning activity in medical technology education.

The evidence available suggested that some areas of health related education—vis. medical technology—might benefit from effective individualized instruction designed for independent study but adaptable in other settings. Therefore, this study proposed that a multimedia individualized specific subject instructional program (MISSIP) might provide data for interim assessment of the effectiveness of an independent study learning experience...in statistics for quality control. It was also proposed that the inclusion of a comprehensive terminal context summary would facilitate achievement of the program objectives. A study utilizing both a programmed instruction booklet and a computer assisted instruction-tutorial evaluation system was
proposed for the purpose of generating data in a tryout phase.

The experimental-development study was designed in three phases that allowed: 1) the development of a validated multimedia individualized instruction program; 2) the implementation of the instructional program in quasi-controlled tryout situations to generate data; and 3) the assessment of the effects of the terminal context summary and effectiveness and efficiency of the individualized program in an independent study situation, as well as identification of indicated program revisions necessary prior to field testing.
CHAPTER II

REVIEW OF RELATED LITERATURE

To provide a background and aid in understanding the development of the program and interpreting the research study findings, this chapter reviews literature which points out the trends toward and research in individualization of instruction--focusing on an independent study situation. Secondly, literature which deals with program design and the research variable is reviewed. Finally, an attempt is made to report literature which describes instructional program evaluation--emphasizing the performance unit and its relationship to the research study and program effectiveness.

**Individualized Instruction in Independent Study**

Individualized instruction and independent study are not synonymous. A learner may be engaged in self-instructional activities within an individualized program; however, on occasions he may interact as part of a group and still be allowed the opportunities of individualized instruction. In an individualized setting, each learner progresses at his own rate through a learning experience which is designed
according to his own needs, interests, capabilities and learning style.

Martin and Persselin contended that education, vis. instruction, should provide every learner with a curriculum designed to meet his needs.\(^1\),\(^2\) However, Martin stressed that "learning is not a spectator's sport. The learner must do things. He must be involved."\(^1\) He further contended that the learner "must be free to go forward, to reverse himself, to repeat in his own style within the broad frame of the program design."\(^1\)

This made it reasonable to understand why Henry Lippert asserted that a quiet change is now taking place in instructional practices, whereby the responsibility for learning is being transferred from the instructor to the student. He went on to give a three part mechanism for making this transfer:

1. Tell the student what knowledge and competencies he is expected to attain;
2. Taking into account what the student already knows, provide the student with information about what he should learn next, how he can learn it and the learning resources by which he can learn;


3. Provide criterion tests on which the student can demonstrate his acquired learnings and competencies.3

Other authors have addressed themselves to the change and point out the need of new instructional techniques:

What appears to be needed are new instructional techniques which are sufficiently powerful to enable a much broader range of students to cope more successfully with diverse curricula than has been true in the past.4

We believe that a great number of well developed self-instructional programs for health care specialties have utility for a wider range of learners..............

.........................

Within reasonable limits we can 'customize' a program for different groups merely by changing a little vocabulary and a few examples.5

In the last analysis, self-instruction is good instruction because it deliberately includes each factor that we now know contributes to good learning. While

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devices, formats and features may change, the heart of individualized learning, the real value of self-instruction, lies in the process by which it is developed, and this, many years from now, will continue to represent a signal contribution to medical education.\(^6\)

Flanagan even went as far as to assert that "the desirability of individualizing instruction is no longer questioned by anyone. The objections to it are concerned chiefly with the application of the theory to classroom conditions."\(^7\)

However, Nichols disagreed, at least in part.

After all is scrutinized about current practices and experimentations with individualized instruction, only one conclusion seems to be justified; It is yet another change in form without change in substance. As an experiment it is valuable. It is not, however, an important addition to current practice.\(^8\)

Just what is the status of the theories and current research concerned with individualized instruction? The

\(^6\)Jerome P. Lysaught, "Research on Self-Instruction: Summary and Generalizations," Ibid., p. 35.


Technology of instruction is based on more than one learning theory. Tennyson and Merrill remarked that:

Instructional theory differs from learning theory in several important areas. Learning is briefly defined as some relatively permanent change in a student's ability to perform some behavior which is not a result of matura-tion. Instruction is the process of deliberately manipulating the environment of an individual so that his behavior is changed in a specific way.

Although this difference was recognized by several authors, specific validated empirical studies are lacking. The need for more basic research in developing instruction was stressed by Gagne and Stolurow. However, Seidel


10 A. A. Lumsdaine, "Educational Technology, Programmed Learning and Instructional Science," in Theories of Learning and Instruction, op. cit., p. 393.


14 Laurence M. Stolurow, "Summary and Perspective," in Self Instruction in Medical Education, ed. by Jerome Lysaught, (Rochester, N.Y.: The Rochester Clearinghouse,
emphasized the need of a bridge between basic research studies and those dealing with applied individualized instruction.\textsuperscript{15} He further indicated that more studies are needed that cover the instructional environment and hierarchically organized material. Nevertheless, learning theory is likely to suggest directions in instructional experimentation, especially as guidelines toward workable developments.

In spite of this lack of applicable theory, interest and development of individualized instructional programs have continued. In reality the differences between psychological learning theory and individualized instruction theory became less important. Programs are being produced in many forms to satisfy many situations. The current trend seemed to be toward greater emphasis on maximizing learning conditions designed to bring about a specific behavioral change.

As one examined current practices it was evident that a combination of Skinner's linear and Crowder's scrambled book styles of learning allowed more freedom and sophistication in the instructional process. Views of theorists

and experimentors varied widely as to the important factors in promoting learning, but many of those reviewed by Briggs agreed that structure and sequencing were important in the design of instruction.\textsuperscript{16} A good individualized program is not a product of intense familiarity with the psychology of learning; nor is it developed by expertise in program structure alone; it requires the collaborative effort of various expertise followed by tryout, review, revision and re-tryout—a continuous process.

Individualization is concerned with a step by step determination of whether learning has in fact taken place. The purpose of programmed individualized instruction is to motivate the learner, identity objectives—preferably based on performance requirements—and attempt to establish learner responsibility in learning. The learner should be able to:

- Relate learning to reality;
- Progress at his own rate, in an acceptable manner;
- Identify his strengths and weaknesses; and
- Review as indicated.

It was recognized that some subject areas, sequence, variable rate of presentation, personal characteristics of the learner and intellectual variables speak loudly for

\textsuperscript{16}Leslie J. Briggs, \textit{Sequencing of Instruction}, op. cit.
individualization. Markee also offered support for individualization in professional education when explaining why medical students make use of self-learning materials. He theorized that the interest might be due to the fact that the professional students of today are the first of a new generation, to arrive at professional education, who have been confronted with such learning material since school-day one—if not before.

Perhaps Crowder summed it up when he indicated that learning is accomplished in a variety of ways and varies according to the characteristics, abilities and present knowledge of the learner, with the type and content of the subject matter, with outside variables and the interactions between these variables. However, history has confirmed that there is no panacea to instruction. No one medium, method or structure is optimally suited to instruction for all individuals.

An extensive search of the literature failed to reveal

17 Leslie J. Briggs, Sequencing of Instruction, op. cit.
reports of an allied health curriculum which offered extensive independent study programs. Most studies were of isolated situation describing single "programmed instruction" studies involving adjunct program evaluation. Some references to these studies are made throughout this chapter.

MISSIP

Structure

Structure determines the appropriate sequencing of materials and modules, as well as the appropriate method or mode of presentation. Early in the development of individualized programs there appeared attempts to provide rules for construction. Nevertheless, the evidence revealed


their extensive use remains in research. The basic design for most individualized instruction programs consisted of behavioral objectives, learning activities and test items, preferably criterion referenced.

In adapting learning methods and materials to a specific individual, Flanagan suggested that:

The concept of 'quality instruction' can be easily extended to indicate the degree to which the task to be learned is structured or organized in such a way, that it is optimally efficient for the specific learner. In discussing the problem Cronbach includes four procedures for adopting instruction to individual differences.25

Stated concisely these were: 1) Vary the time given for completion; 2) Match goals or objectives to the individual; 3) Erase variable entry knowledge by providing pre-entry instruction; and 4) Alter instructional methods.

Branching permits adjustment to individual differences. This type of program allows different routes of progress toward terminal achievement. However, Briggs offered one caution to branching following the student's immediate past performance. Rather, he suggested the inclusion of re-

dundancy and review in order to achieve good retention.26 The crux of the design problem then lies in discovering the proper structure to maximize interaction between instruction and individual abilities.

As mentioned previously, structure includes the appropriate sequence of presentation. Opinions differed on who should control learning—the course designer or the learner. There was also a difference of opinion as to why sequencing is important.27 Several experiments relating to program structure, vis. sequence that have been constructed were categorized by King.28 However, the one type which applied more directly to this study involved the experiments of Gagne' and his associates. Gagne' indicated that the technique of task analysis and sequencing accordingly might be utilized to improve learning, especially in training programs. He indicated that objectives should not purport content but rather they should be used to develop a design for learning.29 The Gagne' experimental approach was to

26 Leslie J. Briggs, Sequence of Instruction, op. cit., pp. 27, 33.
27 Leslie J. Briggs, Sequence of Instruction, op. cit. pp. 27, 33.
29 Robert M. Gagne', The Conditions of Learning, op. cit.
analyze the tasks, present a structure based on the relationships of the competencies involved; sequence as implied by the task structure and evaluate criterion data in terms of the task analysis.

Merrill, in his paradigm of instruction, distinguished the type of behavioral outcomes in reference to conditions of learning and added two additional categories to Gagne's original eight. Merrill, in distinguishing the type of behavioral outcomes, arranged the categories in four levels: emotional, psychomotor, memorization and complex cognitive. Each higher level assumed lower level prerequisites. Merrill's paradigm, which can be operationally defined, is now in the process of validation.

The literature suggested the program design for this study. The goal was to optimize learning by structuring the program on a modified version of Cronback's procedures for individualizing instruction. Gagne's experimental approach was utilized in the preliminary phase in task


31Categories of behavior, Merrill's with Gagne's in parenthesis: Emotional (Signal Learning); Topographic (Stimulus Response), Chaining (Chaining), Complex Skill; Naming, Serial Memory (Verbal Association), Discrete Memory (Multiple Discrimination); Classification (Concept Learning), Analysis (Principle Learning), Problem Solving (Problem Solving).
detailing and validation of the objectives and learning activities.

Structure also includes mode of presentation. One suggested mode of presentation most directly related to this study was the scrambled book. John Howard found the scrambled book to satisfy his ideas of effective learning— for instruction in how to use the library. He wanted to be precise, yet include a "gleam of spirit and a hint of humor"— all compatible with a scrambled book. Howard prepared a self-instruction text for classroom use with freshmen medical students.

The books were distributed following a brief orientation. For the rest of the week the students were on their own. At the end of the week the class met for a discussion session and to complete a questionnaire. Howard reported that this type of instruction reduced the teachers instruction time by two-thirds. Some of the students did not like the instructional method, but 68% were favorable or highly favorable to that type of teaching. Howard concluded his paper by stating that he was "convinced that the scrambled text is the most officious of the self-instruction forms."

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32 John W. Howard, "Self Instruction in Using the Health Sciences Library; A Traveler's Tole," Self Instruction in Medical Education, op. cit.

Certainly one study does not confirm the scramble book as the most officious form for self-instruction. However, the favorable student attitude toward the design did effect further investigation as to the feasibility of that form for the self-evaluation segments in the proposed instructional program.

Terminal Context Summary

A program is presequenced and implies a presentation to the student, not just the source of materials to which the student may expose himself. A program thus has a beginning and an end.\(^{34}\)

Most programmed instruction designers believed that one important factor in program effectiveness was that the sequence of materials should be one which allows learning at its best.

Arousing attention, presenting the relevant stimuli and informing the learner about his expected performance have been studied as events in the early process of instruction. In addition, Holland suggested that a behavior which is known to be relevant to terminal performance is more likely to be learned. He went even further and suggested that

studies are needed that will indicate when, how much, and in what way items may be sequenced.35

Another author which alluded to the context summary concept was Klingstedt.36 He presented six steps for achieving program effectiveness. His third step described content for the summary. This summary or rationale should establish value for the module. In succinct form the summary should indicate why achievement is desirable and explicitly point out the consequences of learning or not learning. Klingstedt believed that once this had been presented, the learner might "see the light" and value the program objectives; but if the program design allowed the learner to proceed, before seeing value in the stated objectives, under achievement might be the consequence. Klingstedt suggested in this case that when the learner finally did see the value he might have forgotten the material.35

From this evidence available it was reasonable to assume that a terminal context summary might help to maximize learning but an extensive search of the literature failed to confirm the assumptions. Not one study was found


36 Joe Lars Klingstedt, "Developing Instructional Modules," op. cit., p. 74.
that specifically investigated the effects of its inclusion in a program. Only Magdaz offered a discussion as to the rationale, sequence and advantages of establishing a context presentation method—and this presentation was offered prior to the pretest. Therefore, in order to gain a greater insight into the effects of a terminal context summary, the present study sequenced the TCS following the entry criterion.

**Multimedia**

Given two or more methods of instruction with the same selected learning outcomes, the methods will differ in their effectiveness with students who have different characteristics. Therefore, more than one sequence or set of materials seemed to be required to optimize learning. Lloyd, reporting on student reactions, supported this contention. However, matching multiple material and media to an


individual's characteristics are difficult under the best of conditions. Klingstedt recommended the inclusion of alternatives such as readings, filmstrips, seminars, slide-tape presentations, computer assisted or programmed instruction. An example of an instructional alternative might be to have the learner listen to a slide tape presentation on a specific concept, practice, review and then provide self-evaluation through programmed or computer assisted instruction. This was the basic format selected for the multimedia individualized specific subject instruction program developed for the present study.

Programmed Instruction Booklet (Scrambled Book)

The literature on programmed instruction revealed contradictory research results concerning principles, concepts and format and their application in programmed instruction construction. However, Blyth asserted that "points

41 Joe Lars Klingstedt, "Developing Instructional Modules," op. cit., p. 74.

42 Thomas Rogers, Ben Boltjes and John Manis, "Self Instructional Units for the Teaching of Medical Microbiology," Instructional Systems in Medical Education, op. cit.


44 Phil Manning, Stephenson Abrahamson, Donald Dennis, "Experience with Three Subject Regulations," Ibid.
of our learning theory have been substantiated beyond refutation, the importance of:

1) the active participation of the student in the process of instruction;

2) reinforcement either immediate or delayed;

3) preparing very detailed specifications for behavioral objectives of instruction;

4) analyzing the instructional problem into a series of steps and preparing instruction in that step-wise fashion;

5) the empirical testing and revision of instructional sequences.\(^{45}\)

Nevertheless, Geis and Chapman seemed to seriously question the importance of reinforcement. Although there was ample evidence that under some circumstances feedback affects performance, the results with regard to programmed instruction are ambiguous.\(^{46}\)

It is, however, doubtful anyone would argue with the third statement as stated. Many would agree that if behavioral objectives were the answer, then detailed

\(^{45}\)John W. Blyth, "Impact of Theory," pp. 159-60.

specifications would be necessary. Moreover, what empirical evidence is available to suggest that students' achievement is better in situations with behavioral objectives than those without? Miles and Robinson believed that there is not an answer and it does not appear that there can be. A study would be biased in favor of a prestated objective in that the criterion test usually reflects the specific objectives. However, if taken from a different perspective, the attributes of objectives might give credibility to their general use in instruction. Miles and Robinson pointed out that "teaching is a goal-directed activity, we need a clear statement of our objectives before proceeding with learning activities."\(^{47}\)

Yost also suggested the importance of behavioral objectives in guiding the outcomes of instruction:

An evaluation in relation to behavioral objectives is capable of pointing out unnecessary redundancies, gaps where information is lacking, points where information is not apparently sequenced to optimize behavioral objective attainment, and weak or strong relevance of the instructional materials to selected school and/or community objectives.\(^{48}\)

\(^{47}\)Miles and Robinson, "Behavioral Objectives," pp. 43-44.

The literature seemed to imply that proper utilization of behavioral objectives rests on the willingness of one to deal with data attesting to one's success in instruction.

Stating of objectives or learning outcomes also facilitates an accurate judgement of content validity. Content validity implies that the task being sampled has been precisely defined. However, just stating objectives does not insure content validity. Validity is situation specific, in that it requires that the objectives be judged valid to a specified task as analyzed. Nevertheless, regardless of design application or acceptance and as previously defined and generally accepted, programmed material includes objectives or learning outcomes—along with associated learning activities and criterion tests.49

After reviewing individualized and programmed instruction literature it seemed obvious that the question for investigation should not be one of whether one method proved superior to another but rather that it proved to be as good as—while providing alternative learning activities which are needed. Then the learner may select according to his own needs, interests and capabilities.

It also seemed reasonable to assume, as Lumsdaine did,

that:

A program needs to be thought of as generating a set of events, from which we can predict learning; a concept of programmed learning that implies a specification of behavioral events on the part of the learner is more powerful than a concept of programmed instruction that connotes only a set of materials or stimuli.50

Hudgins concluded:

The logic and structure of the programmed material seemed obviously much more effective in controlling learning than pacing of the material............ Similarly how the student responds.................

.................
does not seem to be crucial in learning the material, as was originally believed by proponents of teaching machines.51

Briggs suggested the scramble book format of Crowder as one alternative mode of presentation.52 His scrambled book does not read like a book--the progress through the

50 A. A. Lumsdaine, "Educational Technology" in Theories of Learning and Instruction, op. cit., p. 389.


52 Leslie J. Briggs, Sequencing of Instruction, op. cit. p. 82.
the book is determined by learner response. This allows linear or branching programming. The sequence of pages used becomes the function of the learner's performance. Briggs further observed that many programmers adopting the scramble book type also inject humor. He concluded that, regardless of whether the student learns more from this style of presentation, at least such programs should avoid "the dead seriousness of dead easy" copy frames so typical of early linear stimulus response programs.

**Computer Assisted Instruction (CAI)**

CAI is a learner-operated mode of study. Using an on line computer in real time, this instructional tool may be used by the learner in a totally independent and self-directed method of study. The use of computers in instruction permits the learner to acquire material at his own pace and at his own particular level of difficulty. CAI is capable of diagnosing the needs of the learner and then gearing the instructional material to those needs.

The sophistication of the source material presented in this media depends on the skill and expertise of the author, as does any lesson. Working with the programmer, this author may structure the course to account for the diversity of needs of the potential learners.

CAI provides immediate feedback to the learner for constant reinforcement of his performance. When used as a
primary source of learning, CAI may utilize slides, audio tapes, reference books or other audio visual materials as supplements. CAI itself may be utilized as an adjunct resource integrated into a unit of study which uses more conventional media for primary material.

There appeared to be as many definitions of CAI as there were systems in operation. However, there was a general agreement that CAI must include computer controlled learning materials presented to the learner in such a manner that interaction between the learner and the computer is the resultant activity.

Program designers also differed as to modes included in CAI. However, the Drill and Practice, Tutorial and Dialogue modes have been accepted and are utilized extensively.\(^\text{53}\) It is difficult to define the current state of CAI. The survey of the literature revealed many articles but the majority are descriptive reports of programs with little research findings. However, the search did suggest a few capabilities and/or potentials of CAI that might be applied in allied health education—especially in a hospital setting:

1. The possibility of bringing enriched programs to users in a variety of environments where such courses cannot be offered by the instructional staff;

\[\text{----}\]

\(^{53}\) Various modes of computer assisted instruction are defined in Appendix C.
2. Courses based on assumed knowledge...might be used to determine status of the user as well as for instruction and review.

3. Single concept programs might be designed for theory and redundant material, freeing the instructor for guidance and the clinical learning experience.

4. By employing a teletypewriter terminal, the individuals would have a printout for continuous referral.

5. Courses which require specialized knowledge might be programmed so that users at hospitals lacking this expertise might benefit.

6. Benefits of CAI are not restricted to the deprived or slow learners.

These possibilities coupled with the multimedia and the monitoring capabilities of CAI-TES does much toward identifying the capacity of a MISSIP for independent study.

Much of the research was marginal to CAI as an instructional process, but as King put it:

> Since effective computer aided instruction must logically follow a programmed instruction technique which encompasses proven theories of learning and teaching, its effective progress becomes only too evident.\(^\text{54}\)

Grubb, commenting on Schurdah's three mode study (CAI, PI and test with workbook exercises) observed that individualized instruction seemed to offer a real advantage to low ability students without hindering those with higher --

ability. He further commented that the study seemed to indicate that the computer offered advantages to the instructional process and development of theories about instruction.

"There are already computer outlets in 22% of the medical schools." Harless, Brandt and Lucas reported that over 80% of their students using programs, even in the try-out stage, found them to be as good or better than conventional instruction. However, cost is a major factor in acceptance. Dick and Gallagher reported that it "is unlikely that, in the short run, it (CAI) is going to make a significant input on education because of the cost associated with one student utilizing a terminal for relatively long periods of time during each instructional session." Nevertheless, the development of new modes such as simulation and problem solving together with time-sharing might


56 Joseph E. Markee, "Where Are Medical Students" Instruction Systems in Medical Education, op. cit., p. 31.


change the cost/student ratio.

It is the case, however, that CAI represents (1) the most advanced form of systematic, personalized instructional system, and (2) the example for which there exists an abundance of not merely anecdotal but objective and reasonably reliable evidence.\(^{59}\)

One such example reviewed was the pilot program of independent study at the Ohio State University, College of Medicine (PMS).\(^{60}\) PMS was a research project that investigated the effectiveness and efficiency of utilizing selected concepts of independent study in medical education. The charge was to design, implement and evaluate a preclerkship curriculum that would incorporate as its foundation, certain educational principles and tenets of independent study.

After eight months in the curriculum, PMS students were asked their reactions to the program. They expressed considerable satisfaction at being able to progress at their own rate, set their own schedule and pursue interests in various fields. Although few, negative reactions were expressed by more than one student. The more frequent


\(^{60}\)An Abstraction of "A Pilot Program of Independent Study in Medical Education" by James Griesen, et. al., and other materials on CAI are presented in Appendix D.
responses dealt with the need for more detailed instructional objectives and the need for a quiet place to study. Isolated comments related the fact that schedule meetings (not more than three hours per week) interrupted their study schedule and were intrusive. The responses of 31 students revealed that 90% found the CAI tutorial evaluation system helpful or very helpful and that approximately one-third came to rely more on this method of self-evaluation as they progressed through the program.

In summary, the independent study curriculum with CAI self-evaluation has proven to be feasible and learner enthusiasm for the freedom and flexibility of such a program has been expressed.

Dale, as did Lumsdaine and Sjogren, agreed that there is a "social demand" not only for mastery-learning at a stated proficiency level, but that there should be efficiency in learning without a loss in learning outcomes. 63

The desired proficiency level will vary with each situation. The degree of proficiency depends exclusively

A. A. Lumsdaine, "Assessing the Effectiveness of Instruction Programs," in Graser, Data and Directions, p. 310.
upon what use is made of the data. Many times 100% achievement must be obtained and then is only one alternative—success or failure. However, other instances decree a range of proficiency or allow for less than criterion performance. The interest here would be the range or distance from the criterion.

**Criterion Referenced Tests**

One purpose of an entry criterion is to ascertain existing capabilities and/or proficiency. These behaviors, in relation to that specified in the objectives of the learning situation and included in the post criterion, make it possible to determine a performance unit—percentage of objectives achieved by an individual after taking a program, that were not achieved prior to entry. The entry criterion also allows for branching according to achievement. This suggested that it should be possible to detect learning difficulties and provide pre-entry instruction as needed. Branching to exclude already learned material should also increase program efficiency.

When a program aims to assist students to master objectives, criterion referenced rather than norm referenced evaluation is appropriate. The construction of criterion-referenced tests is influenced by several factors. Consideration should be given to them in order that the data generated has application. Of prime importance is the
test items. Shoemaker stressed this fact when stating:

The proportion correct score for a particular examinee or groups of examinees is meaningful only if the items included in the criterion-referenced test constitute a random or stratified random sample from the content population of admissible test items.

Items within a criterion-referenced test should be stratified according to instructional objective and according to difficulty level within each objective.61

According to Sjogren:

Mastery or criterion-referenced tests are used to determine an individual's status on performance standards. This is in contrast with the more commonly used norm-referenced test in which the individual's status is compared with some norm group....Mastery testing regained respectability with the programed instruction movement and now is regarded as a useful measurement procedure.62

Performance Unit (PU)

A test score is the function of a learners inherited


characteristics, his learning and experiences prior to and during the testing situation. All factors should be considered when interpreting performance. Unless all learners enter a program with the same abilities, simple gain scores are not appropriate. In reality entry ability usually varies and meaningful evaluation is then a problem.

Mager addressed this problem and suggested using an index of the percentage gained by the learner in relation to the maximum gain he could have secured (a modified gain score). 64 This score tells us how much behavior the program changed. Mager identified the modified gain score as:

\[
\text{Post test - Pretest} \div \text{Maximum score - Pretest}
\]

and concluded that:

This measure tells us how much possible improvement was actually realized, thereby compensating to some extent for the problem of unequal difficulty along the gain continuum. 65

The modified gain score takes into account what a gain of 10% at the lower end of a gain continuum is not the same.


as a 10% gain at the higher. No matter how much performance is changed, the change is of little value unless the material teaches what it is suppose to teach (a concern of this study). The data available implied that the modified gain score, as based on percent of achievement, allowed for assessment of the instructional materials in terms of the degree to which the materials aided in learning process; what was learned in relationship to what the materials intended to teach--the specified learning outcomes.

**Program Effectiveness**

Every program necessitates study design. Brown suggested a sequence of steps that could be followed in almost any design.

1) Specify the goals of the instructional program, the desired outcomes, and the alternative procedures for attaining these outcomes.

2) Select a sample of students to be used in the evaluation study. These students should be representative of the students for whom the program is designed..............

3) Measure students' standing on relevant characteristics --e.g., their present level of achievement, learning skills and attitudes, personality characteristics. These are imput variables.
4) Apply the instructional program (treatment) to the sample

5) Monitor the effects of the treatment. Although we may only measure achievement at the end of instruction, if we constantly monitor performance, we can better determine when and how learning occurs.

6) Analyze the results and draw conclusions; this is the evaluation phase.

7) Put the results into practice by modifying present procedures or adopting the new method. At this point we essentially begin anew and evaluate the new procedure. 66

These steps formulated the basic design for this study. The actual design is discussed in Chapter III.

Lumsdaine, in "Assessing Instructional Programs" pointed out:

There will, furthermore, be considerable variation among learners in their starting points for programs, as well as variations in the terminal points or levels reached. And in addition to these differences, individual differences in learning ability also lead to variations in how long it takes students to get to any specified level in using

the program. 67

He further suggested in, "Assessing the Effectiveness of Instructional Programs," that there were four alternatives in describing the effects produced by use of a program, but concluded that one may simply resort to reporting two separate sets of facts. This is perhaps the best thing one can do presently since no single achievement/time unit can be defended as a simple figure of merit for a program's instructional efficiency. 69 Lumsdaine's suggestion in regards to utilization of the time unit might be incorporated into research designs. "Time may at least be taken as an abscissa, where ordinal increments show achievement gains--and the ratio of time over gain at least shows an average slope for an 'acquisition curve', that is anchored fore and aft at the initial and terminal points." 70

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68 Lumsdaine's alternatives: 1) Report gains in attainment of outcomes achieved by going through the program from beginning to end and separately report time spent on the program as a second, separate dependent variable; 2) Determine and report as the main dependent variable time required to achieve specified levels of attainment; 3) Hold time constant, reporting attainment achieved in some arbitrarily fixed period of time; 4) Let both time and attainment vary, using some devised single measure such as amount of attainment per unit time.

69 Lumsdaine in Glaser, Data and Directions, p. 310.

70 A. A. Lumsdaine in Filep, p. 256.
Something else should also be known about the program. A modified gain score alone tells us how much behavior a program manages to change, but not if the program is teaching what it intended to teach. The development design should include validation by expert review and evaluation of materials in comparison with the criterion and objectives against the stated evaluation criteria. Green suggested that what is needed is a "set of specifications of what the program does rather than a statistical statement of comparisons with an unknown 'other standard'." Flanagan observed, when reviewing Markle and Short's efforts, that the major gains in efficiency in the programs were the products of repeated empirical tryouts and feedback as to its effectiveness.

Tryouts and field testing are undertaken to ensure continuity, good organization and sequencing, adequate and accurate instruction and to provide an estimate of time involvement. Program evaluation is a series of points on the continuum of program development. It isn't enough to develop a program--it is necessary to develop and modify the

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71Edward J. Green, "The Process of Instructional Programming," in NSSE, Programed Instruction, p. 75.

program until it works—not to satisfy all needs.

Summary

Although the differences between learning and instructional theory were recognized, validation and applied research in instructional theory seemed to be lacking in the allied health professions. The literature revealed that instructional theory had not been validated with experimental research; this would require creating divergent experimental conditions. However, the studies did suggest directions and guidelines for the development and application of individualized instruction.

There was agreement that structure and sequence were important to the design of instruction but expertise in structure and application of the psychology of learning did not alone make a good program.

Since no one medium, method or structure is optimally suited to instruction for all, studies have been conducted which indicate that the inclusion of alternative modes, media and materials aided in adapting the instruction to individual characteristics.

Many of the studies conducted on programmed instruction reported conflicting or non-significant results concerning principles, concepts and format but nevertheless, have been accepted and utilized in program development.

Although not ample in numbers, there was evidence to
suggest that computer assisted instruction, especially the tutorial-self evaluation mode, had proven to be a feasible as one mode for instruction-evaluation and was a flexible media for individualized instruction in an independent study situation.

However, the evidence implied that individualized instruction should meet several conditions:

1) The individual is an active member of the learning process;
2) The learner knows what knowledge and competencies he is expected to obtain;
3) The learning situation is flexible so that the individual may proceed, repeat and achieve specific performance objectives which were identified through diagnostic activities and criterion testing, as essential for him.
4) A variety of media, materials, procedures and resources are available for each objective so that a selection among alternatives is allowable.
5) The learning activities allow the individual to progress at his own pace.
6) Opportunities for self-evaluation are provided throughout the learning situation.
7) Individual progress and attainment is measured by comparing his performance to specified learning outcomes—not with other individuals.
Since this study served two primary purposes (experimental and development), this chapter first discusses the experimental subjects, sampling methods, the experimental design and statistical procedures. Program development and evaluation-revision are discussed in the last two sections.

The study was conducted over a period of eight months, designated as the preliminary-development, experimental and the tryout-revision phases. The preliminary portion was devoted primarily to problem and learner identification, task detailing and objective validation. The experimental design and hypothesis were conceptualized during this phase.

The instructional materials, criterion tests and tutorial-evaluation segments (LOTES) were constructed during the developmental phase. They were also reviewed and revised as indicated in this phase.

The experimental phase, a two month period, not only included the identification and assignment of subjects, but also included conducting the research study, with tryout materials, to generate data for hypothesis testing and
program evaluation.

The retrieval, analysis and interpretation of data in the tryout-revision phase indicated revisions, in the instructional and tutorial-evaluation material, necessary prior to field testing. Field testing of the program was not included in the present study.

The research portion of the study was conducted to:
1) evaluate the effects of a terminal context summary (TCS) presented prior to entry into an individualized instruction program and 2) to determine the effectiveness of the program in a tryout phase. The remaining objectives of the study were to: 1) evaluate the program objectives based on task detailing; 2) develop for field testing an instructional program devoted to basic statistics required for quality control in the clinical laboratory; and 3) to evaluate the instructional materials.

Research Study

Hypothesis

It has been previously stated that the problem of this study was to determine if the degree of explicitness with which the objectives are specified prior to the learning experience influenced terminal objective achievement. It was,
therefore, hypothesized that a terminal context summary\(^1\) would facilitate the achievement of terminal objectives, regardless of the instructional situation or learner background.

In order to statistically test the proposed hypothesis, the following statistical null hypothesis was presented.

Hypothesis:

There is no statistically significant difference between the performance units, at the .05 level of significance, of the terminal context summary group and the no-terminal context summary group, as determined by equated criterion referenced tests.

The following procedures were utilized in testing the hypothesis.

**Experimental Design and Procedures**

Following a randomized pretest-post-test control design, the experimental groups were selected from a volunteer sample frame of 76 health professionals and educators. The frame was randomly divided into two equal groups--terminal context summary (TCS), 39 and no-terminal context summary (NTCS), 39. The TCS group received the cassette tape expanding on the objectives. The NTCS group did not. Both

\(^1\)The TCS is more fully discussed in the Program Development section.
received the objectives in Criterion 1. Further identifications, not directly connected with the problem in question, were made, within each sample, on the basis of statistical background and instructional situation.

The identifications were made on the basis of whether or not the participants had formal instruction in the subject matter or were now actively engaged in quality control and according to the availability of an Ohio Regional Medical Program/Computer Assisted Instruction (ORMP/CAI) Network terminal. No block or stratification was made with this information in testing of the hypothesis. No other distinction was made as to student or active professional, even though the information was recorded.

Sample size was restricted due to insufficient funds to mass produce professionally made materials within the time limits imposed on the study. A delay in production further cut the sample to 13 in each group. In March, 1972 (QUCOST) was made available to the participants at various Schools of Medical Technology, academic institutions, clinical laboratories and interested persons across the nation.²

²University of New York at Albany, University of Pittsburgh; Louisiana State University, University of Illinois Medical Center-Chicago; Mercy Hospital, Denver; Emanuel Hospital, Portland, Ore.; Maricopa Technical College, Phoenix; and in Ohio: College of Mt. St. Joseph, Cincinnati; Good Samaritan, Grandview and St. Elizabeth Hospitals, Dayton; Chas. Kettering Hospital, Kettering; Holzer Clinic, Gallipolis; Altman Hospital, Canton and Licking Co. Hospital, Newark.
At each site, a study coordinator accepted the responsibility for proper distribution of the program materials and TCS cassette, as well as insuring that the experimental instructions were followed.\(^3\)

During the experimental phase, study coordinators, not on the ORMP-CAI Network, received study instructions, one set of six cassettes, one set of 42 slides and scrambled books (PIB) for each participant. The participants obtained their instructions in a booklet which also contained the criterion tests, an opinionnaire, and duplicate response sheets on which were recorded their responses and estimated time involvement. The return of the duplicate sheets made it possible to obtain achievement data and to follow individual response patterns throughout the LOTES.

Study coordinators at institutions on the ORMP-CAI Network received study instructions, a set of six cassettes, one set of 43 slides and booklets for each participant. These booklets contained participant instructions and the opinionnaire which was completed and returned following termination of the program. CAI participants interacted at the terminal for the criterion tests and LOTES. The responses for this group were computer retained and printed out for data analysis. The printouts were checked manually for accuracy.

\(^3\)Complete instructions may be found in Appendix E.
Participant's instructions included explicit directions on experimental procedures and recording. The instructions also emphasized that contrary to the concepts of independent study it was necessary for the purposes of this experiment that only the materials contained within the MISSIP be used. Although the experimental phase, which ended June 1, 1972, was 2 months in duration, each participant had been instructed to complete the program within a two week period of their date of entry. This request had to be made as no definite time scheduled for the various sections was made. The entry and terminal measurements did not span more than two weeks.

In the tryout-revision phase, the PIB responses had to be manually graded, tallied and the percent of achievement and the performance unit (PU) calculated and recorded. Due to programming limitations of the language, the percent of achievement and performance unit of this group were also manually calculated. Once the PU was calculated and recorded, the statistical tests for significance were performed.

Statistical Procedures

The data for each participant were recorded on forms and verified for accuracy. A calculator was utilized in performing the percentages and statistical analyses called for by the research design and program effectiveness
evaluation.

Prior to testing the hypothesis, the objective achievement percentages of each participant was calculated for both criterion tests and within each self evaluation segment. Second, the various means, standard deviations and performance units were computed from these percentages.

A Pearson product-moment coefficient of correlation was calculated to determine the equality of the criterion referenced tests.\(^4\)

The t test for significant differences between means assumes normality of the distribution and homogeneity of variance. Therefore, a modified Pearsonian measure of skewness was calculated and the F ratio was applied to the variances of the research groups.\(^5\)

In testing the research hypothesis, the individual PU, the means and standard deviations of the performance units for the two research groups were utilized. For the data relative to the hypothesis, different populations were tested for significance by computing the Mann-Whitney U


and a t test was applied for the difference between independent means, following the procedures specified by Bruning and Kintz.⁶

Program Development

The need for a multimedia individualized specific subject instruction program (MISSIP) has been documented previously. This section discusses the task detailing, design criteria and development of the learning outcomes, TCS and program materials.

The design followed the methodological procedures of programmed instruction incorporating variations necessary to equate the PIB with the innovative methods and strategies inherent in CAI. The design adhered to stated criteria:

1. State of learning outcomes in terms of measurable behaviors based on a task analysis;
2. Evaluate learning materials during development;
3. Include materials adaptable to a wide variety of entry behaviors;
4. Utilize criterion tests to establish achievement of learning outcomes and for sequencing progress through the Program;
5. Provide developmental instruction as needed;
6. Provide for active participation of the learner in the learning activities, with guidance toward intended outcomes.

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7. Make available information and reinforcement feedback;
8. Allow for the learner to proceed at his own pace;
9. Provide opportunity for review until achievement.

In developing a MISSIP, the first step was to clearly identify the terminal goal or objective for the program.

**Task Detailing**

Basic descriptive statistics for quality control evolved as the relevant subject matter focus for QUCOST following an investigation into the task in question—producing a quality control chart for daily use and precision comparisons of its procedure with others.

Accepting the suggestion of Mager and Beach and utilizing the researcher's 11 years of daily involvement with quality control in the clinical laboratory, the steps perceived to be necessary to the task were listed. The list was ordered and stated in terms of "what is done". A Task Detailing Sheet as shown in Figure 1 resulted.

Also included on the sheet was a column, headed, "Type of Performance—what principal kind of learning is involved with each. A modification of Gagne' "conditions of learn-—______

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FIGURE 1

TASK DETAILING SHEET

<table>
<thead>
<tr>
<th>STEPS IN PERFORMING TASK</th>
<th>TYPE OF PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Collect Data</td>
<td></td>
</tr>
<tr>
<td>1.1 Review Data</td>
<td></td>
</tr>
<tr>
<td>2.0 Total Data</td>
<td></td>
</tr>
<tr>
<td>3.0 Compute Mean</td>
<td></td>
</tr>
<tr>
<td>4.0 Calculate the Mean Deviation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Square the mean deviation</td>
</tr>
<tr>
<td></td>
<td>Sum the Squares</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Square the results (control)</td>
</tr>
<tr>
<td></td>
<td>Sum the squares and</td>
</tr>
<tr>
<td></td>
<td>Square the sum of the results</td>
</tr>
<tr>
<td>5.0 Compute variance</td>
<td></td>
</tr>
<tr>
<td>6.0 Compute standard deviation</td>
<td></td>
</tr>
<tr>
<td>7.0 Determine confidence limits</td>
<td></td>
</tr>
<tr>
<td>8.0 Compute coefficient of variation</td>
<td></td>
</tr>
<tr>
<td>9.0 Construct chart</td>
<td></td>
</tr>
<tr>
<td>10.0 Display chart</td>
<td></td>
</tr>
<tr>
<td>11.0 Plot and interpret daily results*</td>
<td></td>
</tr>
<tr>
<td>12.0 Analyze chart*</td>
<td></td>
</tr>
</tbody>
</table>

*Added in validation
ing" resulted in the following type of performance:\footnote{8}{Robert Gagne', \textit{Conditions of Learning}, op. cit.}
Recall--Knowing what to do, Knowing why to do it;
Discrimination--Knowing when to do it and when it is done;
Problem solving--How to decide what to do;
Manipulation--How to do it.
As the result of the validation, another type of performance was added:
Synthesis and Analysis--Ability to organize and examine critically.
For validation purposes the Task Detailing Sheet was submitted to an expert panel of seven educators in the field of medical technology who have direct contact with or are instructors of quality control in the clinical laboratory. The panel independently evaluated the steps. All seven members agreed, following additions, that the steps were in agreement with task performance.
However since no consensus of opinion evolved as to the type of performance, a review of the learning conditions was made and a new taxonomy evolved.\footnote{9}{The hierarchy presents the learning outcomes according to level of learning:}
\begin{itemize}
  \item Level I  Knowledge--Recall
  \item Level II Interpretation--comprehension
  \item Level III Problem solving--application
  \item Level IV Analysis--synthesis
\end{itemize}
used in creating an hierarchy of learning outcomes.

Learning Outcomes

The detailing described the steps necessary for task performance. The steps identified the learning outcomes essential for a clear statement of instructional intent and the guidelines for learning activities and evaluation of the instruction.

First, basic skills, knowledge and abilities in math were assumed for entry into QUCOST. Next, general learning outcomes were identified and then specific or enabling outcomes were determined:

1.0 Knows the basic elements of Quality Control (QC)
   1.1 Identifies sources of error
   1.2 Describes general method of estimating error
   1.3 Outlines basic steps of QC
   1.4 Defines accuracy
   1.5 Defines precision
   1.6 States reasons for a QC program

2.0 Understands the meaning of statistical terms
   2.1 Distinguishes between parameters and statistics
   2.2 Identifies symbols and symbolic expressions
   2.3 Diagrams and explains a normal curve
   2.4 Distinguishes between measures of central tendency (CT) and dispersion
   2.5 Distinguishes between confidence limits and allowable limits
   2.6 Defends the use of the coefficient of variation

3.0 Understands measures of CT
   3.1 Identifies and defines measures of CT
      3.1.1 mode
      3.1.2 mean
      3.1.3 median
3.2 Explains the relationship of measures of CT in a distribution curve

3.3 Explains, generalizes and gives examples of CT
   3.3.1 mode
   3.3.2 mean
   3.3.3 median

4.0 Calculates measure of CT
   4.1 mean
   4.2 median
   4.3 mode

5.0 Applies measures of CT
   5.1 relates to and uses mean
   5.2 relates to and uses median
   5.3 relates to and uses mode

6.0 Understands measures of dispersion
   6.1 Identifies and defines measures of dispersion
      6.1.1 range
      6.1.2 mean deviation
      6.1.3 variance
      6.1.4 standard deviation
      6.1.5 coefficient of variation (CV)
      6.1.6 confidence limits
   6.2 Explains the relationship of the standard deviation in a distribution curve
   6.3 Explains, generalizes and gives examples of measure of dispersion
      (same as 6.1.1-6.1.6)

7.0 Calculates measures of dispersion
   (same as 6.1.1-6.1.6)

8.0 Applies measures of dispersion
   (same as 6.1.1-6.1.6)

9.0 Analyzes statistics of QC
   9.1 Breaks down QC charts into statistical components
   9.2 Diagrams QC statistics
   9.3 Explains use of chart in QC application
   9.4 Illustrates use of CV
It should be noted that some of the objectives were not directly related with the task detail, vis. those referring to median and mode. However, to fully understand the concepts of a normal curve, an assumption of confidence limits, one had to be aware of the median and the role it plays in one estimation of skewness. Also, with the inclusion of the median and mode, QUCOST became an instructional program, applicable in various situations, on basic descriptive statistics.

The educator panel independently evaluated and validated the learning outcomes or objectives against stated criteria:

1. Does each general objective indicate an appropriate outcome for the occupational task?
2. Is the sequence of learning outcomes logical?
3. Is each objective:
   - action oriented?
   - in terms of student performance?
   - clear?
   - concise?
   - measurable?

4. Is each general learning outcome defined by the list of specific learning outcomes?
5. Does each specific learning outcome specify definite observable behavior?
6. Is the behavior in each specific learning outcome
relevant to the general outcome it describes?

7. Is there a sufficient number of specific learning outcomes to adequately describe the behavior of learners who have achieved each of the general outcomes?

Consistent positive interpretation of the criteria by the panel determined reliability of the objectives. It was prestated that if 5 members of the panel were in positive agreement on the criteria, then the objective could be considered valid. The data in Table 1 showed that on 7 of the 11 criteria there was unanimous positive agreement. The validation produced only 1 disagreement on number 3 as to whether the objectives were clear. On 3 other criteria a "yes" or "no" answer was not recorded, only comments given:

Nos. 2 and 7 = "I do not know"

4 = "It is not evident to me at which place the student prepares a chart. I am assuming this is included in step 8 and 9."

Nevertheless, to insure continued validity of learning activities with objectives and the task performance, there was a review of the completed materials by two persons, with knowledge and experience in the subject matter, prior to tryout. As discussed in a later chapter, the results of the opinionnaire further supported the validity of the learning activities and objectives.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Response</th>
<th>Yes</th>
<th>No</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>1</td>
<td>7</td>
<td></td>
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<tr>
<td></td>
<td>2</td>
<td>6</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>3.1</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>3.2</td>
<td>7</td>
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<td></td>
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<tr>
<td></td>
<td>3.3</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>7</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>3.5</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
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<td></td>
<td>7</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Terminal Context Summary

Approximately 10 minutes in length, this summary was as elaboration on the terminal objectives. Its purpose was to give meaning to the terminal objectives and to allow the learner to organize and/or structure existing knowledge into the context of acceptable terminal performance.

Since the summary also served as the dependent variable of the research study, care was taken not to directly answer any self-evaluation question—only give background as to "why" statistics for quality control. Approximately one minute was given to explaining QUCOST and its role in independent study. The entire script is presented in Appendix F.

Program Materials: (QUCOST)

Before continuing with specific parts of QUCOST, the development of the individualized instruction program is outlined in detail.

Following the identification, detailing and validation of the task and learning outcomes, the design of the specific program was conceived. Realizing that the objectives implied the content, the developmental steps ensued:

- Construct criterion and self-evaluation questions
- Identify general instruction sequence and strategy
- Select media
- Conceptualize and write TCS
Specify instructional sequence and strategies
Anticipate responses
Construct proper feedback
Plan and author scripts
Design slide material
Document material
Select evaluation information
Synthesize CAI program
Program CAI material
Produce slides and cassettes
Review and Revise (author and expert)
Review with learner interaction
Synthesize scrambled book
Review and Revise
Type and edit scrambled book (PIB)
Finalize and off-set PIB
Produce booklet
Devise, construct and produce instructions, response sheets and opinionnaire
Package and distribute PIB materials
Release CAI program to selected institutions.
Each segment of QUCOST was developed as self-evaluation tutorial material in conjunction with specific learning activity tapes (SLAT).

One assumption was made for entry into the program. The learner would know the fundamental operations of
addition, subtraction, multiplication and division, decimal placement and application of same in formulae.

However, included as developmental activities were a tape and slides for review in square root approximation or calculation and a math review.

In brief, QUCOST was developed to provide a simplified approach to the descriptive statistics required in basic quality control—measures of central tendency and dispersion. The program was adaptable for either independent study or group presentation. It was realized that some learners who undertake QUCOST may need additional resource material or personal instruction. At the conclusion of the research study, this approach would be available as required. Adjunct resource material has been obtained from four commercial companies and will be available at each CAI terminal on the ORMP/CAI Network.

Included in the individualized instructional program

---

10 A Workshop on statistics of quality control was held March 12, 1972, Bethesda Hospital, Zanesville, Ohio, for 18 clinical laboratory personnel. The presentation consisted of audio tapes, overhead transparencies and slides (dual viewing of question and data), work sheets and group discussion.

11 Permission to copy or the actual resource materials were contributed by Pfizer Diagnostics, General Diagnostics, Biochemical Procedures and Coulter Diagnostics.
were: an entry criterion; six audio-cassettes containing eight learning activities, two developmental instruction activities and the terminal context summary; 43 demonstration and evaluation slides; 8 tutorial-evaluation segments, available on the Ohio Regional Medical-Computer Assisted Instruction Network or as a programmed instruction booklet (scrambled); a terminal criterion; a dictionary, references and practice data.

QUCOST was not intended to be a comprehensive learning experience or inclusive evaluation for statistics. Rather it was an attempt to help the learner understand the statistical tools utilized in quality control and to help develop skills in application and analysis of basic descriptive statistical measures.

The general learning outcomes, based on task details and distributed to a panel of medical technology educators or quality control experts for validation, served as segment headings.

The tutorial-evaluation segments were programmed in such a manner that progress through the material was individualized according to the learner's responses. However, for the purpose of the research study, branching was not permitted according to responses on the entry criterion. This limitation was made for materials evaluation. High achievers as well as low achievers interacted in all sections.
### TABLE 2

CRITERION ITEM DATA PRESENTING ASSIGNED RELATED LEARNING OUTCOMES AND LEVEL OF LEARNING

<table>
<thead>
<tr>
<th>Entry (C₁)</th>
<th>Terminal (C₂)</th>
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<tbody>
<tr>
<td>Item</td>
<td>Related Level</td>
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<td>17.3(%)</td>
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<td>3</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
Criterion Referenced Tests

Following an initial field test of items, those which matched a specific objective or set of objectives were selected for inclusion in entry and terminal tests to ascertain subject matter knowledge prior to and at completion of QUCOST. All items were based on one or more of the stated learning outcomes and subjectively tagged according to the appropriate outcome and learning level. Tagging items provided a method to weight items according to terminal behavioral significance. A breakdown of the assigned objective and levels is presented in Table 2. Further tabulation of the data, as in Tables 3 and 4, showed the entry criterion to be of equal form with the terminal criterion. This equality was further demonstrated by a correlation of the tests.\textsuperscript{12}

Table 4 was a consolidation made possible by grouping the 9 learning outcomes (LO) into 4 subject matter areas. LO No. 1 and 9 referring to quality control, No. 2 to statistical terms, Nos. 3, 4 and 5 to central tendency and Nos. 6, 7 and 8 to dispersion. The grouping of the outcomes into general subject matter areas provided an additional method to evaluate the instructional program. Not only was it

\textsuperscript{12}Correlation results: \( r = 0.6881, p < .01 \).
possible to determine overall modified gain scores (PU) for each participant, but also on each outcome and in each subject area.

Since the research design of this study included only the tryout phase, no attempt was made in additional field testing of the criterion tests. Indicated revision of the items was made following the research study.

Specific Learning Activity Tapes (SLAT) (Audio-cassette instruction)

When expected professional assistance failed to materialize, the tape lectures had to be written and produced by the author. This decision, made after assessing priorities, proved to be a problem. Many of the criticisms made on the opinionnaire were objections to the quality of the tapes. What actual effect this had on objective achievement cannot be measured directly—only suppositions have been made.

The informative material was written in lecture form. Each script was reviewed and revised prior to recording on a master magnetic cassette—utilizing a Bell and Howell 294K cassette player-recorder. Copies were obtained on magnetic tapes by attaching a Sony TC 100, Solid State player-recorder to the Bell and Howell. Spot checks were made to insure accurate reproduction. Only the informational material for one general outcome was recorded per side. The
scripts, varying in length, required different size cassettes--2 thirty minute, 2 sixty minute and 1 ninety minute. The two remaining sides allowed the inclusion of developmental instruction material explaining calculation of square root as well as a math review. One cassette contained the TCS.

SLATs, augmented with 2x2 slides, presented the necessary information to maximize learning. The subject matter contained in a combination of the two media offered the learner an opportunity to review, to practice and hopefully to assimilate the subject matter necessary for terminal achievement.

Forty-two 2x2 black and white slides, the majority of which were author designed, visually offered illustrations and information throughout the SLATs, LOTES and Criterion tests. Three errors were noted subsequent to distribution but should not have affected criterion measurement—especially in the terminal criterion. Slides 4 and 7 referred to summary data of daily control results for October and January, respectively. The actual mention of N = 31 was omitted. Both slides were referred to and explained prior to the terminal criterion. Slide 35, optional material on N-1, lacked captions for three columns explaining the differences in the variance of samples utilizing N-1 and N in the denominator. Slide 7 symbolized the sum of the squared deviation scores (d) as: \( \sum (x - \bar{x})^2 \) rather than \( \sum (x - \bar{x})^2 \).
Even though this data would have been useful, especially for a learner still relying on the deviation score when calculating the standard deviation, it was not essential. Correct alternative summary data were supplied on the same slide.

Learning Outcome Tutorial-Evaluation Segments (LOTES)

The CAI and PIB material design with due regard to the principles of learning and programming which facilitate individualized learning in an independent study situation, provided an opportunity for learner self-evaluation. The specific learning outcomes dictated the content and criteria for achievement and for learner opportunity of coaching and review in a previous SLAT or DIT.

Since the items in the self-evaluation segments were not presented as test items, per se, they were not tested for validity and reliability. Rather the items were submitted to three experts for their professional judgements as to whether the items were, in fact, measuring the intended behaviors and/or lended themselves to guiding the thought process toward the enabling objective.13

13John Camiscioni, Research Associate and Carol Dawson, Graduate Research Associate, evaluators in Medical Education, College of Medicine, and James Gunnell, Ph.D., Associate Professor, Educational Development Faculty, College of Education, Ohio State University, reviewed the LOTES.
LOTES: CAI. The individualized evaluation consisted of 8 segments with slides and in addition; the criterion tests, a dictionary, practice data and references. Each segment referred to the validated general learning outcomes. The learner's path was author controlled during the experimental phase. Correct responses throughout the program resulted in a linear path but wrong and unanticipated responses led to diagnosis of difficulty, coaching and/or appropriate instruction.

The program draft was constructed using the color-coded form system, "The Author Team's Guide to CAI", by Dr. Armin Weinberg, Project Administrator, Ohio Regional Medical Program/Computer Assisted Instruction Project. This guide utilized prepared forms which divided the construction of the material into four basic sections:

1) Introductory or concluding material to a question or group of questions;

2) The question itself;

3) Responses to the question and appropriate tutorial feedback;

4) Coaching sequences.

The forms, designed to give author flexibility, eliminated the chore of actual coding into computer language. QUCOST was entered in COURSEWRITER III.

The forms served only as a foundation for structuring questions. The strategy and sequence of material remained
the prerogative of the author.

The instructional programmer translated the authors intentions according to computer oriented refinements necessary for successful interaction, instruction and learner evaluation.

A referral was made earlier to diagnosing difficulty in responding to a self-evaluation item. Figures 2 and 3 of a computer printout, shows not only the branching technique utilized in one question but also the tutorial interaction typical throughout QUCOST.14

Following the author review of all anticipated and unanticipated response patterns and the subject matter expert review, revisions necessary for an accurate and flowing program were made.15 In addition to programming time, over 143 hours were involved in authoring approximately 3 1/2 hours of tutorial-evaluation material. Author review and revision accounted for 88 more hours prior to expert review at the terminal. In April, 1972, identification numbers were released to 6 hospital terminals on the ORM-CAI Network.

The network, connected to the Ohio State University Hospital IBM 360 Model 50 computer, utilized IBM 1050 input-

14 The copyright to QUCOST as a CAI program is held by the College of Medicine, Ohio State University.

15 Terminal Review by George Stultz, evaluator, Medical Education, College of Medicine, Ohio State University.
FIGURE 2

CAI: QUESTION SEQUENCE 4.0

4. The calculation of the median heretofore has been approximated by observation.
   And/or count. Using the same data, calculate the median of the scores to the nearest tenth.

Did you listen to the slide-tape presentation, "Calculates Measures of Central Tendency"? (yes/no)

OK, let's see if we can find out where the trouble lies.

Do you know the formula to calculate the median when there are tied scores or when using grouped data? (yes/no)

That is a problem in this exercise, isn't it? DINGBATS: Since you can always find the formula in stat books, it sure isn't a sin -- so hang in there and give the calculation a try. Use the formula: \[ \text{Median} = L + \left( \frac{N/2 - \text{cf}}{f} \right) \times d \] You should have no trouble with it since the interval here is 1.

Now, let's see if you understand the formula... Match the definition listed in column B with its proper symbol listed in column A. (Type a b c OR d)

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. L</td>
<td>a. The frequency of the median score</td>
</tr>
<tr>
<td>2. N</td>
<td>b. The real lower limits of the median score</td>
</tr>
<tr>
<td>3. cf</td>
<td>c. The cumulative frequency up to the median interval</td>
</tr>
<tr>
<td>4. f</td>
<td>d. The total number of scores</td>
</tr>
</tbody>
</table>

No, it's "b"!

Good.

Excellent.

Wonderful. Oh yes, there is one more item we had better check.
FIGURE 3

CAI: QUESTION SEQUENCE 4.0

What is the value of the score class containing the median score?

\[ \text{No, in this set, the score class we are looking for contains the N/2 score.} \]

or 11th score. Since the cf up to 7 is only 10, the median lies somewhere within the
real limits of 8. 6 should not have been considered unless you mistakenly used 11/2.

Are you straightened out now?

The value of \( L \) is 1, cf. is 2, and \( f \) is 3.

The real limits of 8 is 7.5 to 8.5, so \( L = 7.5 \).

\[ \text{Hu, } 2+2+2+6 = 10, \text{ which is cf in this case.} \]

Good.

This is what we have: \( Mdn = 7.5 + 1((11-10)/3) \). The rest should be easy. What is the
Mdn to the nearest tenth?

Well, PENGUIN, putting it all together, the calculations would be:

\[ Mdn = 7.5 + 1/(11-10)/3 \]

\[ Mdn = 7.5 + 3.33333 \]

\[ Mdn = 7.833333, \text{ or to the nearest tenth, } 7.8. \]

Your problem must be math and that is beyond the scope of QUEST. I might just remind
you that it is customary to do the math functions within the quantity before proceeding
with the rest of the formula.

That's the mean and median for now. The mean keeps cropping up time and again as a
component in other calculations, so if you don't feel secure with it, now is the time
to 'firm up the foundation.'
output teletypewriter terminals. The slides were presented via a carrousel slide projector with a rear screen and random access slide seeker attachment. The cassette player was furnished by each participating institution.

LOTES: PIB. The tutorial self-evaluation material was designed in this format to allow greater distribution of the program (to facilities not on the Network) and to offer the learner flexibility in media selection. The branching capabilities of the computer language suggested the form of the scrambled text. Even then, much of the coaching techniques were lost in the transformation. A comparison with CAI can be made by observing Figures 4-12, selected pages from the PIB, and Figures 2 and 3 of a computer printout.

The PIB, author designed, written, typed and compiled, required 355 developmental hours prior to distribution: authoring, 173; revision, 31; and production, 151. Much production time was spent in "slipping" the answers—the best technique found for the money—25 cents, sans labor. (Slips of colored paper covered answers found on the same page as the item.) The format of the booklet allowed the learner to proceed through the program by following coded items and feedback. This technique required that every re-__________

16 The copyright for the slide material, SLAT scrips and PIB is held by Jeanne Burson.
response have an accurate and continuous path to the next item.

When an exercise was presented, the learner considered the question in detail and gave a response. Once the response had been given, the learner continued down the page and proceeded as directed to the number and/or page according to the response.

In some instances the anticipated, or unanticipated response for that matter, had been covered by slips of paper so as not to influence thinking in any way. When ready to check the response, the learner lifted the paper and proceeded as directed to the proper feedback.

In interest of space, some pages contained feedback to two responses but each was set-off by space and/or a dividing symbol.

The following instructions were given the learner in the PIB preface:

REMEMBER---------

1. PROCEED DOWN each page UNLESS asked a question and/or directed to another page.

2. The covered portions should not be revealed until you are ready to check your response.

3. Read and follow directions for your responses only.

4. The feedback should be informative as well as reenforcing and/or corrective in content.

5. Don't flip your lid--just the pages.
9-4C b. Wonderful! 8.1! Your understanding of the statistical methodology included in calculation of the mean appears good—at least increasing.

4D Now how about the median! The calculation of this statistic here to fore has been by observation or approximate count. Now determine the median of the same set of scores—this time to the nearest tenth.

Do you know? No? -- Try page 15.

Yes? △

Well for a Md of 7.5 skip to p. 16. If you don't agree with that maybe you like 7.8 better. 7.8 continues on p. 17. Neither 7.5 or 7.8? Then try p. 15.
What the trouble? Maybe we can pinpoint where the problem lies. Do you know the formula for calculating the \( \text{Mdn} \) when there are tied scores or when using grouped data?

Yes? Then continue on page 18.

No? OK, that can be a problem. Since you can always find it in statistics books, don't get up tight. Hang in there and give it a try. Use the formula:

\[
\text{Mdn} = L + W \left( \frac{N/2 - cf}{f} \right).
\]

You should have no trouble with \( W \), the interval width here is one. Now try it.

Got the median? If so, confirmation is available below. Otherwise there is more info at the bottom of p. 18.

Did you arrive at 7.5 as the median? Well turn to p. 16 and continue. However a median of 7.8 is addressed on p. 17. You didn't get either 7.5 nor 7.8? In that case p. 16, at the bottom, is the place for you.
11-4D  7.5 Did you guess or is the error one of math? By guessing, I imply that you said to yourself, "Well the midpoint of the score is somewhere between 7 and 8." If that is what you did, you are right, but not 7.5. Proceed to p. 20 if you need the limits of the median score or p. 21 for the rest of the data needed to complete the computation.

However if your error is math, check your calculations, find the error and then proceed to p. 22 for feedback.
11-4D You must have thought this one through. The median is 7.3. Since the $\bar{X}$ is 8.1, this suggests a positive skewness in the distribution. The skewness is so slight however, that the curve approaches that of a normal distribution.

For the FINAL WORD in this segment, flip over to that portion found at the bottom of p. 22.
11-15-4D Well, I assume the formula you are thinking of is

\[ \text{Md}n = L + W \frac{(N/2-cf)}{f} \]

The \( W \) is no problem as the interval width is 1.

11-15-4D Now let's see if you understand the formula. Match the definition with its proper symbol. (Give Letter)

1. \( L \) a. The frequency of the median score or class
2. \( N \) b. The real lower limits of the median score or class
3. \( cf \) c. The cumulative frequency up to the median score or class
4. \( f \) d. The total number of scores

COMPLETE THE MATCH AND PROCEED TO THE NEXT PAGE.
11-18-4D  \( L \) = the real lower limits of the median score; \( N \), the total number of scores in the set; \( cf \), the cumulative frequency up to the median score and \( f \) the frequency of the median score.

Oh yes, there is one more thing we had better check.

11-4D  What is the apparent value of the score containing the median score?

When ready continue on p. 20.
The score class we are looking for contains the N/2 score. (Score class here has a width of one) --- 22/2 or the 11th score in the set (not a value of 11). Since the cf up to 7 is only 10, the median lies somewhere within the real limits of 8.

Are things straightened out now?

Just in case there are divergent thoughts at this point, I'll give you a choice.

a. Try the median and check your answer below.

b. Get more help on p. 21.

c. Give up and find the answer on p. 22.

FOR CHOICE "A" CHECK HERE.

If median = 7.5, return to p. 13.
If median = 7.9, then on to p. 23.
If neither, try p. 21.
11-20-4D OK— one more bit of help.

\[ L = 7.5 \]
\[ cf = 10 \]
\[ f = 3 \]

Now put it all together and TRY IT YOURSELF.

Whatever your median may be, continue on p. 22.
FIGURE 12

11-21-4D Putting it all together for calculation:

\[ \text{Mdn} = 7.5 + \frac{10}{1} \times \frac{1}{3} \]

\[ \text{Mdn} = 7.5 + 1(1/3) = 7.5 + 0.333333 \ldots \]

\[ \text{Mdn} = 7.833 \ldots \ldots \text{or to the nearest tenth, 7.8} \]

FINAL WORDS

That's the mean and median for now. We already had lots of practice with observing the mode of a set of numbers. The mean keeps cropping up, time and again, as a component in other statistical measures. So if you do not feel secure with the mean, now is the time to firm up the foundation. When ready, proceed to the SLAT for "Applies Measures of Central Tendency".
The production of the booklet turned out to be a time consuming but learning experience. After the text was written, reviewed, revised, typed (2 pages to each 8 1/2 x 11 sheet) and edited, the booklet still had to be printed, cut, punched, collated, ringed, checked for proper sequence and the answers covered as required.

The tryout booklet distributed was off-set, 8 1/2 x 5 1/2, covered with plastic and held together by 2 rings. Although somewhat unwieldy, this construction allowed the learner to fold back the pages and yet retain a manageable booklet.

The last step in production consisted of labeling, boxing and mailing the required materials to 10 study coordinators for distribution and implementation.

QUCOST was author designed, written and produced with the exception of the art work for 5 slides, slide reproduction, PIB off-setting and CAI programming. Author production was not the original plan. When expected professional assistance failed to meet the production close dates, alternative processes had to be considered. Working within the dissertation time restraints and a non-existent budget, the decision was to self-produce the program. This resulted in a less than perfect professional product. Considering the fact that no outside production funds existed and that the materials were subject to revision following the tryout phase, the decision was made to distribute the resultant
product. At the time of distribution, the product was perceived to be accurate. The aforementioned production errors were not discovered until the author CAI review and revision. In order not to bias the material in favor of the CAI participants, the errors were not corrected before release on the CAI Network.

Actual and estimated production costs for 10 slide and tape sets and 35 booklets (labor not included) were:

Actual costs:

| Supplies  | $ 43.00 |
| Slides    | 105.00  |
| Cassettes | 50.00   |
| Printing  | 145.00  |
| Postage   | 17.00   |
| **Total** | **$360.00** |

Estimated costs:
(professional production--not for profit)

| Supplies  | $ 50.00 |
| Slides    | 315.00  |
| Cassettes | 150.00  |
| Printing  | 250.00  |
| Postage   | 17.00   |
| **Total** | **$782.00** |

The slides and tapes for the terminals were reproduced by the network--cost $88.00. An estimated cost of these sets with professional production was $149.00.

An attempt was made to estimate the cost of instruction. Assuming the availability of a projector, player, $5.00/hour for the 750 developmental hours and disregarding computer
costs,\textsuperscript{17} the actual cost of instruction per hour for the twenty-six participants and ten abortors was $13.81. However, had the entire sample frame completed QUCOST at the same mean rate of involvement as the 26, then the costs of instruction would have been reduced to $5.23/hour.

Klopstein and Seidel projected the cost of instruction in "traditional" professional education to be $2.76.\textsuperscript{18} However, should the MISSIP be produced at a cost of $40.00 per set of tapes and slides and the PIB at $10.00 each, instruction cost per hour for 50 students would be $1.08. This could be decreased even more by reusing the PIB.

\textbf{MISSIP Evaluation}

Since one purpose of the present study was primarily developmental, the program evaluation might have taken one of several forms. One popular method of evaluation is to compare achievement of one form of instruction with another. A second form of program evaluation is to focus on units within a total program in order to identify the degree to which each unit contributed to terminal objective achievement.

\textsuperscript{17}At the present time, terminal costs to network hospitals are at a fixed rate regardless of usage.

ment. A third form of evaluation is concerned with a critical appraisal of the program to determine "what and where" revisions are necessary to improve instructional strategies and facilitate learning. The last method suggested here is to measure, in a controlled situation, the degree to which an instructional program contributes to the learning of pre-stated terminal objectives.

The first form—a comparative study of two instructional methods was not a concern of this study, even though two methods of tutorial evaluation were involved. Rather this study was concerned with the contribution of the MISSIP to pre-stated terminal objectives; the degree to which each segment of the program did contribute to terminal achievement; and the revisions necessary prior to field testing, based on a critical review of the program data and learner responses.

The rationale for inclusion of these three forms of evaluation was derived from the belief that interim evaluation was necessary to measure program effectiveness, prior to the involvement of a large number of persons in a field testing situation.

The interim evaluation, therefore, included: 1) objective validation by experts augmented with participant opinions concerning the validity of the objectives,
content and learning activities;\textsuperscript{19} 2) determination of the appropriateness and completeness of the instructional materials and learning activities; 3) analysis of the data to determine an optimal sequence of instructional content, the correlation of the criterion tests, the effectiveness of the MISSIP as an instructional program and the degree to which each segment contributed toward terminal achievement; and 4) graphic presentations of individual achievement over interaction time.

The objective validation and equality of the criterion tests have been discussed at some length in previous sections of this Chapter. Data for the MISSIP evaluation were obtained from the computer print out of individual responses, response sheets and the opinionnaire.

\textbf{Computer Printout and Response Sheet}

The printout, aside from recording the participant responses, generated data as to: 1) background information; 2) general objective achievement, specific area and total achievement on each criterion; 3) the total correct responses in each LOTES on first try, the number of coachings received and the number of correct responses following

\textsuperscript{19}This validation was discussed in the "Learning Outcomes" section of this Chapter. The results of the opinionnaire are discussed in Chapter IV.
coaches; and 4) time involvement in each LOTES, total time and learner estimated time spent in off-line activities.

The PIB response sheets offered the same information. However, most of the achievement information and total time had to be generated manually.

The Opinionnaire

An 8 item opinionnaire was constructed to obtain information as to the appropriateness and completeness of the instructional materials and learning activities and to determine objective and program content validity.

The instrument consisted of: 1) three items, to be marked on a scale of 1 (never) to 5 (always) as to respondent's opinion on content and objectives; 2) four dichotomous (yes and no) items requested opinion on content, sequence and strategy and 3) the last 3, to be marked on a scale from 1 (no agreement) to 5 (full agreement), were items related specifically to the STAT, slides and LOTES. Space was allotted in all items for additional comments.

The analysis of the opinionnaire (discussed in Chapter IV) was directed toward the differential responses and additional comments made by the participants indicating revision for program improvement. Since the opinions were utilized to augment prior objective/content validation and primarily for identifying the need for program revisions, the opinionnaire was not validated.
Summary

The experimental groups were selected from a volunteer sample frame of health professionals and interested persons. One-half the participants were randomly assigned the terminal context summary. The study was conducted over a period of two months—with individual participation limited to a two-week period.

The performance unit—a modified gain score—was used in testing the research hypothesis: There will be a significant difference between the performance units of the terminal context summary group and the no-terminal context summary group, regardless of instructional situation or participant background. Significant difference was determined by the t test for independent measures and the Mann-Whitney U test.

Criterion referenced entry and terminal tests, based on task details of basic quality control charting, were developed as equal measures for learning outcomes. The tests were not intended as screening or normative devices. Rather in the tryout period, the tests served as evaluative instruments for obtaining the percentage of objective achievement prior to and concluding QUCOST. The data were used to evaluate the effectiveness of the instructional program and for revision of same.

Cassettes were chosen as the method of presentation
for the specific learning activities. The SLAT, as well as, the learning outcome tutorial evaluation segments were augmented with 2x2 film slides to optimize learning.

QUCOST was designed to facilitate individualized learning in an independent study situation. Each general learning outcome constituted a proposed section. The specific learning outcomes suggested the content and criteria for achievement as well as decision points for branching to review, DIT or the next section. The learning activities within the program were constructed with due regard to the principles of learning and programming.

The tutorial-evaluation segments and media were mediated into a format that presented the learner the opportunity to utilize many styles and levels of his thought process. This necessitated several types of questions—including open ended. Information and reinforcement type feedback was utilized as necessary to guide the user to an acceptable response and achievement of the program objectives.

The computer system used was an IBM 360-50. An IBM 1050 teletypewriter terminal presented the learning materials, written in COURSEWRITER III, and recorded the learner's response in the LOTES.

A 213 page booklet served as the LOTES for the non-terminal participants. A response manual accompanied the booklet to provide the learner with information, instructions, and the criterion tests and to obtain responses for
data collection. Both instructional situations necessitated the availability of a 2x2 slide projector, screen and cassette player.

The effectiveness of the program was assessed by utilizing individual and group objective achievement/time ratios and responses obtained from an opinionnaire.
CHAPTER IV

ANALYSIS OF THE DATA

This chapter reports the findings and offers a brief discussion of the statistical procedures employed to test the research hypothesis presented in Chapter III. The research study is considered separately and the findings interpreted in terms of their practical value and meaning.

The interim evaluation of the multimedia individualized instructional program (MISSIP) is centered primarily on objective achievement used to demonstrate the effectiveness of the MISSIP as an instructional program for independent study. The evaluation data are presented and briefly discussed. Time as a variable is considered separately. The analysis of the opinionnaire responses focuses on the differential responses and additional comments made by the participants in regards to the appropriateness and completeness of the learning activities and tutorial-self-evaluation segments.

Research Study

Statistical Assumptions
The hypothesis stated that the terminal context summary would facilitate learning by individuals regardless of their statistical background. Since this variable was identified for all participants prior to treatment, a grouping of results was made to test if the performance units (PU) of the statistic/no-statistics groups were from the same or different populations. As stated previously, interactions between participant background and the terminal contest summary was not a major concern of this study. Therefore, a Mann-Whitney U test, not an analysis of variance, was utilized in identifying what if any effect the statistical background might have on the research problem. The data, presented in Table 5 did not allow rejection of the null hypothesis; therefore, supporting the assumption that statistical background was not an influencing factor in maximum gain achievement. Although there was a 19.9% objective achievement difference between the means of the two groups upon entry. The terminal criterion difference was only 4.6%. The 53.6% PU for the no-statistics group was 2.3% higher than the statistic group, indicating that in this case the no-statistic group learned more of what they could learn than the statistic group. The Mann-Whitney U was not significant at .05 level.

The equality of the two criterion tests was demonstrated by the data in Table 6. Both tests had the same number of possible answers and related objective points.
### TABLE 5

GROUP MEANS ($\bar{X}$) STANDARD DEVIATIONS ($s$) AND MEAN PERFORMANCE UNITS (PU) FOR STATISTICS AND NO-STATISTICS BACKGROUND GROUPS ON THE ENTRY ($C_1$) AND TERMINAL ($C_2$) TESTS

<table>
<thead>
<tr>
<th>Groups</th>
<th>Achievement Percentage</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$C_1$</td>
<td>$C_2$</td>
<td>PU</td>
</tr>
<tr>
<td></td>
<td>$\bar{X}$</td>
<td>$s$</td>
<td>$\bar{X}$</td>
<td>$s$</td>
</tr>
<tr>
<td>Statistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($n = 13$)</td>
<td>65.4</td>
<td>18.41</td>
<td>77.9</td>
<td>17.05</td>
</tr>
<tr>
<td>No-Statistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($n = 13$)</td>
<td>45.5</td>
<td>11.96</td>
<td>73.3</td>
<td>20.70</td>
</tr>
</tbody>
</table>

$^a$Mann-Whitney U of 83 is not significant at .05
TABLE 6
COMPARISON DATA FOR THE TERMINAL CONTEXT SUMMARY (TCS) AND NO-TERMINAL CONTEXT SUMMARY (NTCS) GROUPS ON THE ENTRY (C₁) AND TERMINAL (C₂) CRITERION REFERENCED TESTS

<table>
<thead>
<tr>
<th></th>
<th>TCS (n = 13)</th>
<th>NTCS (n = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C₁</td>
<td>C₂</td>
</tr>
<tr>
<td>No. of Items</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>No. of Possible Answers</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Total Related Objective Points</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Correlation (r)</td>
<td>(0.6358^a)</td>
<td>(0.7293^b)</td>
</tr>
<tr>
<td>(C₁ - C₂) by groups total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ a = p < .02 \]
\[ b = p < .01 \]
The total correlation or parallel forms reliability measure, of .6889, as well as that within each group, exceeded the .05 level of significance demonstrating equivalence and stability of the tests. These statistics, based on variability, are not essential in demonstrating reliability of criterion referenced tests. However, this high correlation does support the equality discussed in Chapter III.

The t test for significant difference between means assumes normality of the distribution and homogeneity of variance of the variables in the populations from which the samples were drawn. The F ratio was used to test the hypothesis of equal variance of the two independent research groups. A "F", at 12 degrees freedom, of 1.29, as shown in Table 7, was less than 2.69, the F value at the .05 level. Therefore, the hypothesis was retained and homogeneity of variance was assumed.

Utilizing a modified Pearsonian measure of skewness to estimate the degree of asymmetry of the distributions, it was determined that the non-terminal context summary group


<table>
<thead>
<tr>
<th>Statistic</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCS</td>
</tr>
<tr>
<td><strong>Groups (n=13)</strong></td>
<td>(n=13)</td>
</tr>
<tr>
<td><strong>Median (Mdn)</strong></td>
<td>54.4</td>
</tr>
<tr>
<td><strong>Pearsonian Skewness (Skp)</strong></td>
<td>+ 0.144</td>
</tr>
<tr>
<td><strong>Coefficient of Variance</strong></td>
<td>57.9</td>
</tr>
<tr>
<td><strong>Variance (s^2)</strong></td>
<td>1049.49</td>
</tr>
<tr>
<td><strong>Homogeneity of Variance (F)</strong></td>
<td>1.29</td>
</tr>
</tbody>
</table>
was indeed negatively skewed, -1.29 as shown in Table 7, beyond the expected skewness value for the assumption of a normal curve. A skewness value higher than +/-or lower than -1 is rarely found in most practical applications. 3

Nevertheless, according to Ferguson,

A number of investigators have studied the effect of non-normal populations on the t test for small samples. The empirical evidence suggests that even for quite small samples, say of the order of 5 or 10, reasonably large departures from normality will not seriously affect the estimation of probabilities for a two tailed t test. 4

Therefore, assuming homogeneity of variance and accepting the statement by Ferguson, a "t" test for significance between the independent group means was performed as described below.

Comparison of Research Groups

The related objective points for each participant were converted to percent of objective achievement and individual performance units for each objective, four subject areas and the total criterion test. Table 8 summarized the data in


### TABLE 8
MEANS, STANDARD DEVIATIONS, AND PERFORMANCE UNITS OF OBJECTIVE ACHIEVEMENT PERCENTAGE ON $C_1$ AND $C_2$ FOR THE TCS AND NTCS GROUPS

<table>
<thead>
<tr>
<th>Group</th>
<th>Test</th>
<th>N</th>
<th>% Objective</th>
<th>Achievement</th>
<th>PU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\bar{X}$</td>
<td>$s$</td>
</tr>
<tr>
<td>TCS</td>
<td></td>
<td></td>
<td></td>
<td>$\bar{X}$</td>
<td>$s$</td>
</tr>
<tr>
<td>$C_1$</td>
<td>13</td>
<td>56.46</td>
<td>19.85</td>
<td>55.96</td>
<td>32.39</td>
</tr>
<tr>
<td>$C_2$</td>
<td>13</td>
<td>79.12</td>
<td>14.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NTCS</td>
<td></td>
<td></td>
<td></td>
<td>$\bar{X}$</td>
<td>$s$</td>
</tr>
<tr>
<td>$C_1$</td>
<td>13</td>
<td>54.43</td>
<td>17.01</td>
<td>48.86</td>
<td>36.80</td>
</tr>
<tr>
<td>$C_2$</td>
<td>13</td>
<td>74.07</td>
<td>22.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
terms of the group mean, standard deviation and performance units of objective achievement percentage for the total tests. The subject area objective achievement percentages are presented in Tables 11 and 12.

It was hypothesized that a terminal context summary would facilitate the achievement of terminal objectives regardless of the instructional situation or learner background. Table 9 summarized the results of the t test for independent measures, using the individual performance unit as the dependent variable. The t value of .5228 offered no evidence to support rejection of the null hypothesis that there is no significant difference in the performance units of the two groups, at the .05 level of significance, as determined by equated criterion referenced tests.

It was suggested that significance might be obtained had a non-parametric method, which is independent of the shape of the distribution, been utilized. A review of Table 7 showed there to be a 10.3% difference in the median performance units of the two experimental groups. However, the higher value was that of the median for the control group. In order not to be biased toward the research hypothesis, a Mann-Whitney U test, a powerful parametric alternative to the t-test, was performed to test the null hypothesis: that the performances of the TCS and NTCS
TABLE 9

T TEST FOR SIGNIFICANCE BETWEEN THE
MEAN PERFORMANCE UNITS OF THE TCS
AND NTCS GROUPS

<table>
<thead>
<tr>
<th>Group</th>
<th>( \bar{X} )</th>
<th>s</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>55.96</td>
<td>32.39</td>
<td>24</td>
<td>.522a</td>
</tr>
<tr>
<td>NTCS</td>
<td>48.86</td>
<td>36.80</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

\( ^{a}p > .05 \)

groups were the same.\(^5\) The data, as summarized in Table 10, revealed the U to be 75 which did not allow rejection of the null hypothesis. Therefore, it was concluded that in this case there was no significant difference in the

TABLE 10
MANN-WHITNEY U TEST FOR SIGNIFICANCE
BETWEEN THE PERFORMANCE UNITS
OF THE TCS AND NTCS GROUPS

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Sum of Ranks</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>13</td>
<td>185</td>
<td>75a</td>
</tr>
<tr>
<td>NTCS</td>
<td>13</td>
<td>166</td>
<td>94</td>
</tr>
</tbody>
</table>

\[ a = p > .05 \]

performance units, as determined by equated criterion referenced tests, for the terminal context summary and the no-terminal context summary groups.

However, interpretation of the data in Tables 11, 12, 13 and 14 indicated that with the exception of three incidents the TCS group did consistently better in the
subject matter areas, self evaluation segments and in question level achievement. The implication of this consistency is discussed in Chapter V.

**Interim MISSIP Evaluation**

The achievement percentages obtained from the criterion referenced tests provided a second type of information. The percentages were evaluated to provide information about the effectiveness of the instructional materials.

Criterion referenced data allowed alternative program evaluation—group and individual. This type of assessment not only permitted evaluation of terminal behaviors but also provided evidence as to how, in terms of interim achievement, terminal achievement was obtained.

**By Group Assessment:** TCS/NTCS

Average performance in QUCOST was utilized to assess the learning activities and self-evaluation segments. First, group performance on the criterion was analyzed in the four subject areas of quality control, statistical

---

6"Statistical Terms" PU: TCS = 59.0%, NTCS = 66.9%; "Level II Type of Learning" PU: TCS = 65.9, NTCS = 68.5; LOTES, 4.0: Without Coach, TCS = 50.9%, NTCS = 69.2% With Coaching, TCS = 63.1%, NTCS = 69.2%
terms, central tendency and dispersion. The classifications were formed by combining the related objective points on the tests and the segments as follows:

Quality Control—Objectives 1.0, 9.0 and segments 1.0, 8.0
Statistical Terms—Objectives 2.0 and segments 2.0
Central Tendency—Objectives 3.0, 4.0, 5.0 and segments 3.0, 4.0, 5.0
Dispersion—Objectives 6.0, 7.0, 8.0 and segments 6.0, 7.0

As indicated in Table 11 the experimental groups were considered separately to allow interpretation in regards to the research study.

Performance on Criterion Tests

Table 11 shows the group objective achievement which was converted in Table 12 to present the group maximum gain score, the PU. It was evident from the means in Table 11, each group showed an improvement, in each area, toward terminal objective achievement. In fact, three cells; TCS/QC, TCS/ST and N-TCS/ST, demonstrated over 80% of the specified terminal behaviors. Just how much of that help was provided by the instructional materials or was a chance gain is hard to establish. However, Table 11 provided data that permitted an interpretation of group performance based on what was the percent of the terminal behavior not
TABLE 11

GROUP MEANS AND STANDARD DEVIATIONS OF OBJECTIVE ACHIEVEMENT PERCENTAGE FOR THE TCS -- NTCS GROUPS IN FOUR SUBJECT AREAS OF C₁ AND C₂

<table>
<thead>
<tr>
<th>Area</th>
<th>Group</th>
<th>test</th>
<th>TCS</th>
<th>NTCS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>s</td>
<td>X</td>
</tr>
<tr>
<td>Quality Control</td>
<td></td>
<td>C₁</td>
<td>68.08</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C₂</td>
<td>87.19</td>
<td>18.2</td>
</tr>
<tr>
<td>Statistical Terms</td>
<td></td>
<td>C₁</td>
<td>62.46</td>
<td>21.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C₂</td>
<td>84.62</td>
<td>15.4</td>
</tr>
<tr>
<td>Central Tendency</td>
<td></td>
<td>C₁</td>
<td>58.74</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C₂</td>
<td>70.0</td>
<td>18.3</td>
</tr>
<tr>
<td>Dispersion</td>
<td></td>
<td>C₁</td>
<td>47.94</td>
<td>26.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C₂</td>
<td>72.19</td>
<td>24.4</td>
</tr>
</tbody>
</table>
TABLE 12

PERFORMANCE UNIT PERCENTAGE MEANS

FOR THE TCS AND NTCS GROUPS IN

FOUR SUBJECT AREAS OF C₁ AND C₂

<table>
<thead>
<tr>
<th>Area</th>
<th>Group</th>
<th>TCS</th>
<th>NTCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Control</td>
<td></td>
<td>65.2</td>
<td>16.7</td>
</tr>
<tr>
<td>Statistical Terms</td>
<td></td>
<td>59.0</td>
<td>66.9</td>
</tr>
<tr>
<td>Central Tendency</td>
<td></td>
<td>49.1</td>
<td>31.1</td>
</tr>
<tr>
<td>Dispersion</td>
<td></td>
<td>46.6</td>
<td>45.3</td>
</tr>
</tbody>
</table>

exhibited prior to entry into the individualized program.

The data in Tables 12 and 14 indicated that, as the level of the expected learning outcomes progressed from knowing to understanding and applying to analyzing, the maximum group gain decreased.
Performance in LOTES

One explanation for this decrease was provided by observing the group performance in each of the eight segments of the self-evaluation material. Table 13 revealed two deviate scores in the TCS group which suggested a weakness in segments 4.0 and 7.0—two segments focusing on calculations. This weakness was mentioned in the opinionnaire discussed later in this chapter.

The 16.7% maximum gain found in Table 12 for the N-TCS group in quality control was a marked deviation from the other performance units. It was rationalized that this specific decrease might have direct relationship to the TCS—not provided this group.

Levels of Learning: Achievement

In addition to achievement in subject matter context, the evaluation of the instructional materials was also directed toward improved problem solving, applying and analyzing behaviors. As expected the percentage of achievement decreased as the level of the question (1-4) proceeded up the hierarchy of learning. One exception noted in Table 14 is the 68.5% PU of the NTCS group at level two. This correlated with the fact that the group also showed an unexpected and unexplainable percentage increase in statistical terms, which has a general learning outcome at the second
### TABLE 13

Mean Objective Achievement Percentages for the TCS and NTCS Groups Without and Following Coaching in Eight Tutorial-Evaluation Segments (LOTES)

<table>
<thead>
<tr>
<th>Segment</th>
<th>TCS Group</th>
<th>NTCS Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W/O</td>
<td>W</td>
</tr>
<tr>
<td>1.0</td>
<td>76.9</td>
<td>80.8</td>
</tr>
<tr>
<td>2.0</td>
<td>75.6</td>
<td>82.8</td>
</tr>
<tr>
<td>3.0</td>
<td>86.9</td>
<td>87.4</td>
</tr>
<tr>
<td>4.0</td>
<td>50.9</td>
<td>63.1</td>
</tr>
<tr>
<td>5.0</td>
<td>83.7</td>
<td>83.7</td>
</tr>
<tr>
<td>6.0</td>
<td>87.3</td>
<td>88.2</td>
</tr>
<tr>
<td>7.0</td>
<td>68.1</td>
<td>75.1</td>
</tr>
<tr>
<td>8.0</td>
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### TABLE 14

MEANS, STANDARD DEVIATIONS AND MEAN PERFORMANCE UNITS OF QUESTION LEVEL ACHIEVEMENT PERCENTAGES FOR TCS AND NTCS GROUPS ON C₁ AND C₂

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level of the learning hierarchy—"Understands the Meaning of Statistical Terms".

By Individual Assessment

As discussed, the group performance analysis was important in determining the effectiveness of the instruction materials and indicating areas of needed revision. However, individual performance had to be considered.

The primary purpose of criterion referenced measures is to compare individuals with some established criterion rather than with other individuals—what the individual can do. From an instruction materials perspective, this means, what did the materials do for each individual. Did the material ensure mastery? If not, to what degree did the materials contribute toward terminal achievement?

Performance on Criterion Tests/LOTES

An analysis of the data in Tables 15, 16, 17, and 18 revealed that only two individuals achieved mastery (100%) on criterion 2 in all four areas. However 4 individuals showed an approximate 100% gain in at least 3 areas, 5 in 2 areas and 6 in one area. Nine individuals did not obtain an 100% gain in any subject matter area.

On Table 15 it was found that 12 individuals had a maximum approximate PU of 100% in quality control. No one was in the 80-99% range, but 1 obtained at least 70%
**TABLE 15**

LEARNER OBJECTIVE ACHIEVEMENT PERCENTAGES AND APPROXIMATE PU ON C₁ AND C₂ AND OBJECTIVE ACHIEVEMENT PERCENTAGES IN THE QUALITY CONTROL SEGMENTS OF THE LOTES FOR TCS AND NTCS GROUPS

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and 2 at least 50%.

It was indicated by a review of Table 16 that an approximate 100% maximum gain was exhibited by 9 individuals in statistical terms, while 2 showed at least an 80% gain; 3 at least 70% and 60% each. One individual managed to exhibit a 50% maximum gain.

The maximum gains in central tendency and dispersion, as presented in Tables 17 and 18, exhibited the decrease but are essentially the same:

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This analysis of the four areas suggested that approximately 58% of the individuals achieved a maximum gain of 50% or better in each of the subject matter areas on the terminal criterion as well as the criterion as a whole. However, since the eventual aim of a program with stated objectives should foster 100% achievement, the 36--100% PU's
TABLE 16

LEARNER OBJECTIVE ACHIEVEMENT PERCENTAGES AND APPROXIMATE PU ON C₁ AND C₂ AND OBJECTIVE ACHIEVEMENT PERCENTAGES IN THE STATISTICAL TERMS SEGMENTS OF THE LOTES FOR TCS AND NTCS GROUPS

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</tr>
<tr>
<td></td>
<td>4</td>
<td>38.5</td>
<td>52.4</td>
<td>30.8</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td>46.2</td>
<td>88.5</td>
<td>92.3</td>
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</tr>
<tr>
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<td>69.0</td>
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</tr>
<tr>
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<td>53.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>61.5</td>
<td>96.5</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>23.1</td>
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<td>92.5</td>
<td>69.2</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>30.8</td>
<td>89.4</td>
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<td></td>
</tr>
<tr>
<td></td>
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<td>69.2</td>
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</tr>
<tr>
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<td>100.0</td>
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<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
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<td>100.0</td>
<td></td>
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<tr>
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<td>3</td>
<td>46.2</td>
<td>93.5</td>
<td>92.3</td>
<td>85.6</td>
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<td></td>
<td>4</td>
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<td>90.0</td>
<td>30.8</td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td>38.5</td>
<td>56.1</td>
<td>38.5</td>
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</tr>
<tr>
<td></td>
<td>6</td>
<td>53.9</td>
<td>94.1</td>
<td>100.0</td>
<td>100.0</td>
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<tr>
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<td>85.6</td>
<td>92.3</td>
<td>85.6</td>
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</tr>
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<td></td>
<td>8</td>
<td>76.9</td>
<td>85.6</td>
<td>92.3</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>53.9</td>
<td>54.6</td>
<td>53.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15.4</td>
<td>40.9</td>
<td>30.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>23.1</td>
<td>61.2</td>
<td>46.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>46.2</td>
<td>85.6</td>
<td>92.3</td>
<td>85.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>30.8</td>
<td>69.8</td>
<td>30.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
out of a possible 104 suggested further assessment of the learning situations.

**By Performance: Sub Groups**

The analysis of the data on Tables 15, 16, 17, and 18 prompted the reorganization of data into those who showed less than 50% objective achievement on $C_1$ and those with 50% or more objective achievement on $C_1$. A look at their PU's in Table 19 showed that the median maximum gain, by those satisfying more than one-half the terminal objectives upon entry, was 73.5%. Whereas, those, who upon entry were able to exhibit less than one-half the terminal objectives, had a maximum gain percentage of only 47.5%. This 26% difference was not significant when tested by the Mann-Whitney U, at the .05 level, but did suggest further investigation.

Yet another grouping of the PU's, according to professional and/or educational backgrounds, allowed another assessment of the instructional materials. Table 19 showed the mean and median PU's of the student, active and educational medical technologist groups to be approximately the same—54-56% and 59-65%. However, the health professionals in other than the profession of medical technology exhibited only a 38.9% mean and 42.2% median. The interesting fact of this difference is footnoted to Table 19. The two individuals from the original TCS group had maximum gains of 71.4%
### TABLE 19

**PERFORMANCE UNITS BY ENTRY OBJECTIVE ACHIEVEMENT AND PROFESSIONAL AND/OR EDUCATIONAL BACKGROUND GROUPINGS**

<table>
<thead>
<tr>
<th>Groupings</th>
<th>&lt;50% on C₁</th>
<th>&gt;50% on C₂</th>
<th>Student MT</th>
<th>Active MT³</th>
<th>Educ.² MT</th>
<th>NON MT¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>10</td>
<td>16</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU</td>
<td>43.8</td>
<td>63.4</td>
<td>54.9</td>
<td>54.1</td>
<td>56.6</td>
<td>38.9ᵇ</td>
</tr>
<tr>
<td>Mdn</td>
<td>47.5</td>
<td>73.5ᵃ</td>
<td>64.7</td>
<td>60.0</td>
<td>59.0</td>
<td>42.2</td>
</tr>
</tbody>
</table>

¹ physical therapist  
¹¹ medical educator  
² health related profession educators  
³ mean years of experience = 8.3  
³¹ mean years of experience = 6.5  
ᵃ Mann-Whitney U not significant at .05  
ᵇ TCS, PU = 71.4 and 54.4%  
NTCS, PU = 30 and 0%
and 54.4%. Of the two who did not receive the terminal context summary, one made only a 30% maximum gain and the other had a PU of 0%. No test of significance was attempted for this 2x2 comparison. However, the question remains, had the N been larger would the differences still have been as great.

**Time as a Variable**

In an attempt to assess the achievement/time problem, the individual performance units were plotted graphically and expressed as a ratio of maximum gain divided by hours of interaction in the eight segments of QUCOST. It was obvious from the graph in Figure 13 and the hours listed in Table 20 that the variability in individual time and achievement is great and no distinct pattern exists. Excluding the one divergent 71.4% PU per 31.4 hours of interaction, the other 25 ranged erratically in time from 64%/4.8 hours to 32%/17.5 hours.

Figures 14 and 15, as suggested by Lumsdaine, graphically displayed the "acquisition line" for each participant in each experimental group. The C1 objective achievement percentage was anchored at 0 hours of time. The C2 objective achievement percentage, was anchored at the

7A. A. Lumsdaine, in Felip, *Prospectives in Programming*, op. cit., p. 256.
FIGURE 13

INDIVIDUAL PU OVER HOURS INTERACTION IN 8 SEGMENTS OF QCOST WITH MEAN AND MEDIAN MAXIMUM ACHIEVEMENT/INTERACTION LINE

○ TCS  △ NTCS
INDIVIDUAL TOTAL OBJECTIVE ACHIEVEMENT PERCENTAGES ON C-1 AND C-2 OVER INTERACTION HOURS WITH MAXIMUM GAIN PER HOUR NOTED (TCS GROUP)
FIGURE 15

INDIVIDUAL TOTAL OBJECTIVE ACHIEVEMENT PERCENTAGES ON C-1 AND C-2 OVER INTERACTION HOURS WITH MAXIMUM GAIN PER HOUR NOTED (NTCS GROUP)
individual's total interaction time for the 8 segments of QUCOST.

An observation of the graphs plainly showed the variation of objective achievement. No two lines were the same. Individuals starting at the same point (shown by circled dots) followed a different line of acquisition toward terminal achievement.

Even though Lumsdaine asserted that no single achievement-time ratio or unit could be defended as a simple figure, a PU-interaction time unit was computed for each individual. This relative ratio led to an interesting finding in regards to the group median of the ratios belonging to participants who showed less than 50% objective achievement on C1.

In Table 20 the individual maximum gain per hour of interaction is listed. Here one can see another wide range showing individual differences. The ratios ranged from -0.5% per hour to 17.3% per hour. This large variability was further emphasized by the data of Table 21, which presented the total mean and median for the two groups.

It was noted in Table 19 that a non-significant 26% difference existed in the median PU's of the TCS and N-TCS groups. The individuals in each group, who obtained less

---

8A. A. Lumsdaine in Filip, op. cit., p. 255.
TABLE 20

TERMINAL PUS, INTERACTION TIME AND MAXIMUM GAIN PER HOUR RATIOS IN THE SELF-EVALUATION SEGMENTS

<table>
<thead>
<tr>
<th>TCS</th>
<th>PU</th>
<th>hours</th>
<th>max. gain/hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>6.6</td>
<td></td>
<td>15.1</td>
</tr>
<tr>
<td>100.0</td>
<td>6.3</td>
<td></td>
<td>16.0</td>
</tr>
<tr>
<td>0.0</td>
<td>8.3</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>16.0</td>
<td>5.8</td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>93.6</td>
<td>5.4</td>
<td></td>
<td>17.3</td>
</tr>
<tr>
<td>71.4</td>
<td>31.4</td>
<td></td>
<td>2.3b</td>
</tr>
<tr>
<td>41.6</td>
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<td></td>
<td>5.6b</td>
</tr>
<tr>
<td>74.8</td>
<td>8.2</td>
<td></td>
<td>9.1</td>
</tr>
<tr>
<td>36.2</td>
<td>7.2</td>
<td></td>
<td>5.0b</td>
</tr>
<tr>
<td>21.4</td>
<td>10.5</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>50.0</td>
<td>12.1</td>
<td></td>
<td>4.1b</td>
</tr>
<tr>
<td>68.1</td>
<td>12.5</td>
<td></td>
<td>5.4b</td>
</tr>
<tr>
<td>54.4</td>
<td>5.8</td>
<td></td>
<td>9.4</td>
</tr>
<tr>
<td>NTCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60.0</td>
<td>8.3</td>
<td></td>
<td>7.2</td>
</tr>
<tr>
<td>94.3</td>
<td>6.9</td>
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<td>13.6</td>
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<tr>
<td>78.6</td>
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<td>64.7</td>
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<td>13.5</td>
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<td>93.9</td>
<td>5.8</td>
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<td>88.6</td>
<td>11.6</td>
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<td>7.6</td>
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<td>- 4.0</td>
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<td>-0.5a</td>
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</tr>
<tr>
<td>0.0</td>
<td>8.3</td>
<td></td>
<td>0.0a</td>
</tr>
</tbody>
</table>

*aobtained 50% on C1; \( \bar{X} = 4.5\%; \text{Mdn} = 5\%*

*bobtained 50% on C1; \( \bar{X} = 1.9\%; \text{Mdn} = 1.8\%*

*cMann-Whitney U significant (H_0, \ p=.048) 1 tailed*
TABLE 21
TCS AND NTCS GROUP AND TOTAL MEANS AND
MEDIANs MAXIMUM GAIN/Hr. RATIOS

<table>
<thead>
<tr>
<th>Maximum Gain Percentage/hour</th>
<th>TCS</th>
<th>NTCS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.2</td>
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<td>7.0</td>
</tr>
<tr>
<td>Median</td>
<td>5.4</td>
<td>7.2</td>
<td>5.6</td>
</tr>
</tbody>
</table>

than 50% achievement on $C_1$, were identified among the ratios on Table 20. A test of significance was made on the achievement/time ratios to determine if the TCS group had a significantly larger maximum gain/hour (Mdn = 5%/hr) than the N-TCS group (Mdn = 1.8%/hr). The Mann-Whitney U applied to the data gave evidence, at the .05 level, that supported this hypothesis.

The group mean interaction time in minutes for each
LOTES and learning activity segment is presented in Table 22. This information was combined and a group-subject area achievement/total time ratio was calculated. The combination, summarized in Table 23 indicated another deviation. Why was the NTCS group mean percentage gain/hour so much more (46.45) in statistical terms than in the other areas? It had been expected that the mean maximum gain/hr would be less in central tendency and dispersion, as these units contained several calculations. Nevertheless, a 50% decrease was not expected.

Opinionnaire: Response Data

The evaluation opinionnaire, completed by the participants concluding criterion 2, was primarily focused on program content: in terms of the agreement of the content and activities with the specified learning outcomes; the manner in which the materials were sequenced and utilized; the instructional value to the learner; and comments for revision.

The participants were instructed on the first three items to mark their opinion on a scale from 1 (never) to 5 (always). Space was provided for additional comments.

Item 1: The information contained in the learning activities agreed with the stated learning outcomes.
TABLE 22
MEAN INTERACTION TIME (MINUTES) FOR TCS AND NTCS GROUPS IN THE EIGHT TUTORIAL-EVALUATION (LOTES) AND LEARNING ACTIVITY SEGMENTS (SLATS)

<table>
<thead>
<tr>
<th>Segments</th>
<th>LOTES</th>
<th>SLATS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCS</td>
<td>NTCS</td>
</tr>
<tr>
<td>1.0</td>
<td>14.2</td>
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<td>5.0</td>
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<td>25.5</td>
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<td>6.0</td>
<td>18.3</td>
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<tr>
<td>7.0</td>
<td>48.6</td>
<td>40.0</td>
</tr>
<tr>
<td>8.0</td>
<td>15.3</td>
<td>17.7</td>
</tr>
</tbody>
</table>
TABLE 23
MEAN PU ON C₂, MEAN HOURS IN LOTES AND
MEAN MAXIMUM GAIN/HR. FOR TCS AND
NTCS IN THE FOUR SUBJECT AREAS

<table>
<thead>
<tr>
<th>Areas</th>
<th>TCS</th>
<th>NTCS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PU</td>
<td>hrs.</td>
</tr>
<tr>
<td>Quality Control</td>
<td>65.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Statistical Terms</td>
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<td>1.5</td>
</tr>
<tr>
<td>Central Tendency</td>
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</tr>
<tr>
<td>Dispersion</td>
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</tr>
</tbody>
</table>
Item 2: The learning materials offered the necessary information and activities for terminal objective achievement.

<table>
<thead>
<tr>
<th>Scale</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response tally: total</td>
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<td>2</td>
<td>4</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>TCS</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>N-TCS</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

Item 3: The enabling objectives, as criteria presented in the tutorial-evaluation segments were appropriate for terminal achievement.

<table>
<thead>
<tr>
<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tally: Total</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>TCS</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>N-TCS</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

These items attempted to support the validation of the specified learning outcomes with instructional materials. Assuming the scale to be in 25% increments, it was evident from the tabulation that 19 out of the 26 considered the learning activities in 75% agreement with the stated learning outcomes. All but two shared the same opinion at 50% agreement. In addition to the favorable statements, the
comments given here were not that the activities disagreed with the outcomes but that there was a need for more calculation practice. This suggestion really applied to item 2.

In response to item 2, there was one mention of the errors on slides 4, 7, and 35. The omissions were noted following the circulation of the PIB's and prior to the CAI release. However, because the errors need not directly affect the results and in order not to bias the study, the errors were not corrected at that time. The slide masters have since been corrected. The total response in Item 2 also showed a 19—75% agreement.

Only one less—18, agreed that 75% of the enabling objectives or LOTES criteria were appropriate for terminal achievement.

Item 4. was the first of four dichotomous (yes and no) items.

Are all parts of the learning activities needed for attainment of the terminal objectives?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>N-TCS</td>
<td>8</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Twenty out of 26 considered that all parts of the learning activities were essential for terminal achievement.
There was one mention of an excess of material but this excess was not identified. Aside from one comment concerning the voice on the tape, the others were complimentary and praised the use of self-evaluation prior to terminal assessment. The one response most typical of several on the opinionnaire was: There is excess material, but just for me. This might be needed for someone else. What is good about the format is that we know what is to be learned.

Item 5. Are there gaps where information is lacking?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>N-TCS</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

Ten of the participants believed that information gaps existed. Three referred to the slide errors and 2 believed that all data referred to on the tapes should have been presented on slides. Several of the comments focused on suggested additions to the content, especially the need for more instruction with the math review, developmental instructional slides and expansion of the reference to the F Test. Aside from one suggestion for more explanation and practice with confidence limits, these suggestions did not apply to the main instructional program.
Item 6. Are the learning activities presented in an optimal sequence for student attainment?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>N-TCS</td>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

The only comment applicable here was one for duplicate slides to facilitate flow and avoid returning to a slide utilized previously.

The last of the "yes and no" items referred to the coaching sequences.

Item 7. Are the coaching sequences helpful?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCS</td>
<td>11</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>N-TCS</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Two participants liked the book format but found it confusing to return to the original question while still in a coaching sequence. One person, who had a PU of 16%, thought the coaching sequences took too much time. The other comments focused on the benefits of reenforcement-tutorial instruction.

The next three items referred specifically to the learning activity tapes, the slides and the self-evaluation
Item 8. As utilized in QUCOST:

8.1. The SLATS are:

8.1.1. an appropriate media for learning

(1 = no agreement, to 5 = full agreement)

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As expected the majority of the comments focused on the reproduction and voice quality of the tapes. The participants accepted the media and thought the content informative but not always audible. Only two individuals preferred
written material to cassettes. Even though opinions varied greatly, 14 were in agreement that the tapes were appropriate media for learning, 15 agreed that they were meaningful and only 1 found them not informative at all. The comments of those in full agreement on all three criteria stressed the usage of tapes as an excellent media for learning because:

You can proceed at your own rate;

The lecturer went slow and explained all the information (this is a comment of the -4% PU);

You can rewind and review a vague point.

Item 8.2. The Slides are:
  8.2.1. an appropriate media for learning

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The previously mentioned comments concerning duplicate slides and a desire to have the data on paper were repeated here. There were also two responses indicating that some slides were crowded and needed to be better organized. Several liked the opportunity to visualize. The tabulation tended to support this opportunity. Twenty-four agreed that the slides were an appropriate media; 21 found them meaningful and 24 agreed they were informative.

**Item 8.3.** The LOTES are:

8.3.1. an appropriate method for self-evaluation

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Four learners said that they found the LOTES to be a good method for learning but were somewhat confused when flipping the pages—two of the four were those who had trouble finding the original question.

A few of the additional comments were appropriate, meaningful and directed toward program improvement. Suggested utilization was considered. The following were excerpts noteworthy of inclusion in this analysis of responses:

"The LOTES are what actually adds to the complete program. Without them I think the benefits of the SLATS and slides would be totally lost. It really clarified ideas and gave a better insight into concepts misunderstood. The only problem existing here was the difficulty in finding answers."
In addition, the difficulty of finding the original place or question after finding appropriate answers."

"I think printed material would be much less tiring for the student than the SLATS, and it would enable him to progress at his own rate. I found myself frustrated at times because the Slat was too slow and at other times because the SLAT was too fast, even though the speaker maintained essentially the same tempo. Generally, however, the program is excellent. The presentation of the concept of the CV was really brilliant." "Would have preferred an 8 1/2 x 11 sheet size if possible, so that number of pages would be shortened." "As a complete program, QUCOST will be a good learning experience."
CHAPTER V

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of the problem, research, MISSIP development and findings of this experimental research-development study. Conclusions are drawn from the study and recommendations are made based on the conclusions and implications.

Summary

Problem-Purpose

A review of contemporary educational thoughts in the health related professions, revealed a new interest in curriculum revision and continuing education programs with a focus on the individual.

The need for planned and orderly educational experiences designed to achieve effective objectives was seldom denied. But health personnel are individuals with their own set of interest, emotional, mental and practical experiences. Therefore, no one method or educational experience is a means in itself.

165
The national, state and local professional societies, hospitals, colleges, universities, Regional Medical Programs, commercial supply houses, publishing companies and the routine "coffee-break" are answering the cry for learning experiences that deal with the factors that confront the individual. The learning experiences are flexible but many times are inaccessible and/or unrelated to the individual's specific deficiency or need.

Recognizing the concern for the individual and documenting the need for accessible specific learning activities, the development of a specific subject program (MISSIP) for independent study was proposed to provide an effective learning experience for health related personnel with divergent cognitive backgrounds.

This study investigated the effects of a terminal context summary in a multimedia individualized instructional approach to statistics for quality control. The three-phase study was designed to:

1) Develop a multimedia individualized program in basic descriptive statistics for quality control (QUCOST);

2) Answer the question: Does the degree of explicitness with which the objectives are specified prior to a learning experience influence terminal objective achievement;

3) Assess the effectiveness of the individualized
program in a quasi controlled tryout phase and make program revisions as indicated prior to field testing to a larger population.

The Development Phase

The terminal goals for the MISSIP were identified as the learning outcomes necessary in producing a quality control chart and in procedure comparisons.

The tasks and associated general and specific learning outcomes were validated by an expert panel of seven educators in the field of medical technology and two persons with knowledge and experience in the subject matter.

QUCOST was developed to provide a simplified approach to the descriptive statistics required in basic quality control—measures of central tendency and dispersion. The program was adaptable for either independent study or group presentation. It was realized that some learners who undertake QUCOST may need additional resource material or personal instruction. However, for the purpose of the study, only the instructional materials self-contained in QUCOST were utilized. Adjunct resource material has been obtained from four laboratory supply companies to be available for referral at the terminal centers of the OSRMP-CAI Network.

Included in the individualized instruction program were: an entry criterion; six audio-cassettes containing eight learning activities, two developmental instructional
activities; and the terminal context summary; 43 demonstration and evaluation slides; 8 tutorial-evaluation segments, available on the OSRMP-CAI Network (360-50 computer, 1050 teletypewriter terminal, COURSEWRITER III language) and as a programmed instruction booklet (PIB) (scrambled); a terminal criterion; a dictionary and references. An expanded practice section was added in revision.

The design of the program intended to individualize instruction and optimize learning regardless of the instructional situation or learner background.

With the exception of the computer programming, the instructional audio tapes, equated criterion referenced tests, slides and self-evaluation segments were author written and produced. In addition to the programming time, approximately 750 hours and $360.00 were consumed in authoring, revising and producing the MISSIP. In April and May, 1972, the MISSIP was distributed for tryout to volunteer participants throughout United States.

The Experimental Phase

The research problem as previously stated was to determine if the degree of explicitness with which the objectives were specified prior to the learning experience influenced terminal objective achievement. It was, therefore, hypothesized that a terminal context summary, which gave meaning to the specified objectives and allowed for
organization and structure of existing knowledge into the proper context, would facilitate the achievement of the expected outcomes.

The methodology of this study was designed to test the statistical null hypothesis that: There is no statistically significant difference between the performance units, at the .05 level of significance, of the terminal context summary group (TCS) and the no-terminal context summary (NTCS), as determined by equated criterion referenced tests.

The volunteer sample frame consisted of 76 health professionals and two educators. Two groups of 39 were randomly created from this frame. One group, the experimental or TCS group was required to listen to the introductory audio tape expanding on the terminal objectives, while the other group, the control or NTCS, were not. Both groups completed equated entry and terminal criterion tests of 30 responses with 38 related objective points.

Thirteen participants in each group satisfactorily completed the program, tests and evaluation opinionnaire within the specified two-week interaction period. The PIB participant response sheets were returned to the experimenter for manual grading. Although the computer generated data for participants who utilized CAI in the self-evaluation segments, all responses were manually checked to ensure credit for acceptable answers and to identify revisions needed in the programming.
The Tryout-Revision Phase

Effects of a Terminal Context Summary

Statistical measures showed:

1) By a significant positive correlation that the two criterion referenced tests were parallel forms which exhibited equivalence and stability;

2) The group data to have homogeneity of variance although the NTCS group distribution was negatively skewed beyond assumption of a normal curve; and

3) That, in this case, a statistical background, or lack there of, did not significantly effect the maximum achievement score (PU) of the learner.

An analysis of the data, generated by the t test for independent samples and the Mann-Whitney U, revealed that no significant difference existed in the performance units of the two groups on the criterion tests. Consequently the null hypothesis of no significant difference was upheld.

The research hypothesis, however, stated that the terminal context summary would facilitate terminal objective achievement. Facilitate was defined as to make easier or less difficult and assist in the progress of the learner. This definition implied not only significant achievement but consistent progress toward terminal achievement in a least amount of time. Results that suggested effects of the TCS were:
1) With the exception of statistical terms objective achievement and level II achievement percentage on the terminal criterion and segment 4.0 in the self-evaluation segments, the TCS group did consistently better in the subject matter areas, self-evaluation segments and in question level achievement;

2) The only 100% PU's (terminal) were in the TCS group;

3) Twenty-one out of a possible 52 of the TCS performances in the subject matter areas of the criterion tests demonstrated 100% maximum gain and 34 of 52 performances showed at least a 50% gain; in comparison, the NTCS group exhibited 15 of 52 100% gains and 27 of 52 made a 50% or more gain.

4) Although the time reported was only estimations, the mean maximum percentage gain/hour for the TCS group was 7.24%--the NTCS group 6.81%. The group medians were 5.4 and 7.2% respectively.

5) For the two TCS health professionals in a field other than medical technology, the mean PU was 62.9%; the NTCS group mean PU was 15%;

6) A Mann-Whitney U test gave evidence at the .05 level to support the hypothesis: that the TCS participants with less than 50% achievement on \(C_1\) will exhibit a greater maximum gain/hour than those in the NTCS group.
7) The deviate 16.7% mean PU for the NTCS group in the quality control area indicated a deficiency not exhibited by the TCS group (62.5%);

8) The NTCS group demonstrated less than 80% objective achievement in all areas on the criterion tests and in the LOTES, except for statistical terms on C and "Understand Measures of Dispersion" in the LOTES; and

9) The mean PU for the TCS group on Level 4 questions was 36.1% compared to the NTCS group mean PU of 19.6%.

MISSIP Evaluation

Achievement.--The random sample of participants produced a wide range of learner achievements and interaction times. This variation however, was used to make objective and subjective decisions as to the attainability of the terminal behaviors, the significance of the sequenced instruction, the value of the diagnostic and coaching branches, the appropriateness of the media and materials and revisions prior to field testing.

The assessment, utilizing criterion referenced data, permitted group averages and individual performance evaluation of the specified terminal and enabling outcomes and associated learning activities. Thus was created a behavior repertoire of each participant in the various segments of
QUCOST under quasi controlled conditions (sans outside resource material).

Since it is almost impossible to get everyone to complete mastery, especially in independent study where one method is usually not the means to the end for all, the data were analyzed at various levels of achievement. The criterion tests, SLATS and LOTES were evaluated totally and in each subject matter area, in terms of group and individual performance at levels over 50% PU. Everyone who got the same percent of achievement did not obtain the score in essentially the same manner.

A 80% group mean objective achievement in the subject matter areas of $C_2$ and the LOTES was considered sufficient for tryout materials. As was expected the areas encompassing the calculating objectives had the lower percent of achievement. Since dispersion achievement depends, in part, on central tendency achievement, the decrease in dispersion to 72% was not unexpected.

However, assuming valid objectives, the need for revision or additional instructional material was indicated, especially when considering individual differences as shown in the PU. This unit was based on what an individual achieved in relation to what he was expected to achieve at any one stage of the program.

Although the percentage of objective achievement of the TCS group on Level IV type question (application, analysis
and synthesis) was consistent with the other levels, the maximum gain percentage decrease to 36.1% should be noted and considered when revisions are made.

With the noted exceptions, the quality control and statistical terms objective achievement percentages and PU's indicate a consistent increase toward mastery. The central tendency and dispersion percentage decreases, in specific incidents, showed the need of improvement in those areas, even though the coaching sequences added, on the average, 4-5% achievement in most incidents.

**Time.**—The graphic display of achievement over time offered little indication of any existing patterns. Individual differences exhibited increased variability. Therefore, a second plotting was made which more clearly demonstrated the individual differences by anchoring the $C_1$ objective achievement percentage at 0 hours and creating a "line of acquisition" by plotting the $C_2$ percentage over the total individual interaction time in the eight segments of QUCOST. This type of presentation clearly showed that even though individuals started at the same level of objective achievement, they had created different lines of acquisition at the termination of QUCOST. The variation was also noted in the relative figures established by the achievement-time ratio.

Grouping the participants according to performance on $C_1$ (above and below 50% achievement) offered yet another
method to evaluate the instructional materials. The 19.6% mean and a 26% median difference between the two new groupings suggested that even though the difference was not statistically significant, the materials were not assisting maximum achievement of the individuals with less than 50% initial achievement the same as those with 50% or over. The only statistically significant difference found when breaking down the new groupings was the difference between the TCS and NTCS participants who had less than 50% objective achievement upon entry.

Opinionnaire.—The analysis of the opinionnaire responses focused on appropriateness and completeness of the learning activities and self-evaluation segments. The additional suggestions for revision supported the analysis of the achievement percentages. Although most of the ratings indicated the material, media and methods already included in QUCOST were valid, appropriate, meaningful, informative, in proper sequence and were needed for objective achievement, more practice and/or examples needed to be included in sections requiring calculations.

The most repeated objection to the media selection focused on the reproduction quality, not the content, of the audio cassette tapes. Over all sections and across all media, the majority of the ratings (50-75%) of QUCOST suggested its appropriateness as an instructional program.
This was exemplified by the comments that in total QUCOST should provide a good learning experience for independent study in statistics of quality control.

**Significance of the Study**

This experimental-development study generated data from a small sample, and investigated the effects of a terminal context summary received prior to entry into the learning activities of an individualized instruction program on statistics of quality control. Although statistical significance was not measured by the maximum gain scores of the experimental and control groups, the design of the study did provide evidence to suggest that the summary did, in this case, facilitate objective achievement at different levels of learning, in specific subject areas within the program and by individuals without a medical technology background.

The maximum gain score, as utilized in this study, provided data that clearly indicated areas for program revision in the learning activities as well as in the self-evaluation segments.

This study also generated a framework and instruments for validation of program objectives based on task detailing.

Finally, although not a direct concern of this study, the data generated and the opinions received suggested that the scrambled booklet format, utilized as one method for tutorial-self-evaluation, did suggest an alternative method
for diagnosing cognitive deficiencies and individualizing instruction. The booklet and computer assisted instruction permitted branching with coaching and review as indicated by individual response. These alternative methods, when not in a controlled situation, should allow individual progress through the instructional materials as indicated by the entry criterion, thus adding to the efficiency of the program.

Conclusions

First considering the major question this study proposed to answer, and based on the evidence presented in Chapter IV, the following conclusions are presented:

1) The terminal context summary, as developed and presented in this study, with a small sample, does not significantly affect total terminal objective achievement of learners demonstrating 50% or more terminal achievement on an entry criterion.

2) Accepting the achievement/time ratio as a relative measure of efficiency, the terminal context summary, as developed and presented in this study, does significantly effect the efficiency of learners exhibiting less than 50% terminal objective achievement on the entry criterion. This conclusion was also clearly indicated when observing the maximum achievement of the less than 50% achievers
on C. By subject areas:

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3) The evidence, though limited to four cases, does imply in this case that a terminal context summary facilitates terminal achievement for learners who have a limited prior knowledge of the specific subject matter.

4) There is conflicting evidence in this study as to whether the degree of explicitness with which the objectives are specified prior to instruction influences terminal objective achievement.

5) Collective evidence generated by tryout data from this study does support the author's contention that a terminal context summary facilitates terminal objective achievement.

In light of this evidence the author refrains from drawing any definite conclusion about the overall effect of a terminal context summary.

Other conclusions:

1) As a result of this study, a multimedia individualized specific subject instruction program on
basic descriptive statistics utilized in quality control was developed from validated objectives and learning experiences. Also stable and reliable equated criterion referenced tests were constructed.

2) Students, active practitioners and educators in medical technology utilizing QUCOST demonstrated no significant difference in maximum gain achievement.

3) Criterion referenced measures and the modified (maximum) gain score provide evidence for evaluation of the effectiveness of instructional materials. The criterion referenced measures are based on specified learning outcomes (validated) and the modified gain score measures how much was learned in relation to that needed to be learned. Reviewing the instructional materials in light of this information provides an opportunity to detect the weaknesses and strength of the various modules or sections of a program. Materials referring to each outcome may be examined specifically and revisions made accordingly.

4) When criterion referenced, a relative maximum objective achievement-time ratio is an useful index for evaluating efficiency as effected by the individualized instructional materials. Additions to or revisions of the instructional materials may
be made to provide information to optimize learning for each outcome and at various levels of achievement.

5) Learners with less than 50% objective achievement upon entry into QUCOST were not equally assisted toward terminal achievement as were those exhibiting 50% or more objective achievement on the entry criterion.

6) The mathematical derivation of the modified gain score needs to be clarified.

7) Minor programming changes in the self-evaluation segments are indicated.

8) The decrease in objective achievement in the subject matter areas of central tendency and dispersion indicates that drill and practice should be added in those sections.

9) The scrambled booklet and computer assisted instruction offered acceptable alternative methods for tutorial self-evaluation. The scrambles format and the capabilities of the computer allowed for diagnosing of cognitive deficiencies and individualizing of instruction by permitting branching for tutoring and review as indicated by individual response.

10) The recording quality of the audio cassettes is of prime importance in the acceptance of a media for
As a result of the research, development, analysis and conclusions, the following recommendations are proposed:

1) Further research might explore the effects of a terminal context summary with: a) a larger homogeneous sample; b) a larger more heterogenic population, vis. other than medical technology; and c) other specific subject programs. It is clear that some effects of the TCS were noticable but without more extensive use of a TCS concept valid judgements are impossible.

2) Until further investigations are made and significant results are obtained to the contrary, the TCS concept should be utilized— at least as optional material.

3) Inquiry should be made into the validity of the modified gain score. Although the experimental research of this study was not directly affected by the occurrence of a 100% achievement on the Criterion 1, the possibility might occur in other controlled investigations. This situation gives a 0 for the denominator. An approximate subject area PU was obtained in this study by assuming total achievement on $C_1$ was 99 not 100%.
4) Further studies should be made to determine more appropriate statistical measures and/or evaluation methods for criterion referenced measures and modified gain scores. The "traditional" methods based on variability might prove to be inappropriate in other cases.

5) QUCOST, following revisions and inclusion of drill and practice sections, should be field tested to a larger population following the principles and concepts of independent study. The TCS should be identified, explained and offered as optional material, as the developmental instruction tapes. All sections should be optional or entered as indicated by achievement on $C_1$.

6) The slide and tape materials should be reproduced as printed copy. This would provide a selection from alternative methods of instruction as the learner or situation dictates.

7) Multimedia individualized instruction programs should be developed in other specific subjects. This would not only provide individualized accessible learning activities but would also make available other programs already evaluated prior to inclusion into a research study.
PURPOSE

To determine the need, general objectives and expected utilization of CAI programs in the basic information essential to medical technology.

This report of the findings—objective, subjective and anecdotal—of the survey concerning CAI in medical technology continuing education has been prefaced with the survey questions:

What types of "educational programs" now exist?
Does CAI have a place in medical technology education?
What type of programs should be given top priority?
Is "release-time" given for educational programs?

Letters and personal and phone interviews were utilized in seeking answers to the questions. Twelve pathologists and 25 medical technology personnel were contacted in 12 participating hospitals.
RESPONSES

WHAT TYPE OF PROGRAMS NOW EXIST?

Schools of Medical Technology and Medical Laboratory Technology
Structured and unstructured on-the-job training or retraining
"Spasmodic" in-service informative meetings
Laboratory proficiency testing
Available resource materials—ASCP continuing education materials and Technical Improvement Service membership
Commercial and professional continuing education offerings

DOES CAI HAVE A PLACE IN MEDICAL TECHNOLOGY EDUCATION?

Yes, as refresher for previous experienced personnel.
Sounds good for on the job training.
Might help determine what "gets through".
Programs must contain reference suggestions.
Maybe, if you start with basic math.
Produce something to convince us.
They do not use what we now provide.
Medical technology personnel are just too tired to stick around for any continuing education.
How could you get them back on a Saturday just to sit at a terminal?
I am not sure--what do you mean?
I did not realize that there was a need until you told us.
Our students are waiting for just that.
Depends on the program.
If I knew how CAI could be utilized, I might be able to give better feedback.

TOP PRIORITY PROGRAMS?
CONSENSUS

TYPE
Short, basic, specific
Informative as well as evaluative
Should lean toward "why" not "how"

SUBJECT
Basic math, enzymes, quality control stat, automation, jaundice, hematology slides, blood gases, antibodies, coagulation...just to list a few.

RELEASE TIME GIVEN?

Any time they are not busy
I plan to schedule them for my students.
Day just too busy
Give me relevant programs and I back you all the way.
Yes, even though it means a 4 mile trip to the terminal. Better 1 or 2—than 1/2 the work force.

I plan to arrange a schedule.

CONCLUSION

The majority of those interviewed seemed eager toward the idea. Action will depend on the product and its acceptance.

Hospital administration can no longer avoid the fact that continuing education for allied health professionals is necessary for continued practice in the changing health care world.

Whatever programs are conceived, there must be direction—or chaos will persist. The problem, if we are to accomplish our goals in the knowledge implosion response to the knowledge explosion—is bringing knowledge and application together to maximize learning.

Jeanne Burson, MT(ASCP) MS Consultant
April 7, 1971
APPENDIX B

OHIO REGIONAL MEDICAL PROGRAM /
COMPUTER ASSISTED INSTRUCTION NETWORK
The Regional Medical Program Computer Assisted Instruction program is the largest network involved in medical education of which we are aware. C.A.I. has developed courses for the use of practitioners who are physicians, nurses, dietitians and auxiliary medical personnel and for students in the health care field.

In the fourteen hospitals presently on the system,¹ courses are used as essential components of orientation programs, continuing education efforts, service-consultation and format curricula. Approximately thirty-three courses are currently available and operational with eighteen additional courses in the developmental stages. The courses vary in type and in audience from "Ventricular Arrhythmias" prepared for coronary nurses to "Care of and Feeding by Veins" a course in development on intravenous therapy for adults and/or children which includes individual tracks for

¹Three community hospital terminals to be added in July-Aug. 1972.
physicians, medical students, nurses, nursing students and emergency medical technicians.

The participating community hospitals use on-line teletypewriters with real-time access to the course materials stored in the memory bank of an IBM 360/50 computer at the Ohio State University. The core staff of the project identifies the needs of the community health team and provides the instructional courses to meet those needs.

Courses are designed to be used singularly as primary resources or as adjunct materials for instructional units. Audio-visuals in the form of slides and audio-tapes may be included in the learner package. Service courses are also available which utilize the capabilities of the computer for such tasks as diet planning and analysis.

Various models of instruction are available including overviews, reviews, case studies, simulation and tutorial self-evaluation.

Instructional materials are geared to the many members of the health team including physicians, nurses, clinical laboratory personnel, dietitians, occupational and physical therapists, LPN's, aides, medical secretaries and emergency medical technicians. There are also patient education courses.

Examples of the various areas in which course material exists are as follows:
Basic Statistics  
Anatomy  
Physiology  
Chemistry  
Histology  
Terminology  
Acid-base and electrolytes  
Nursing Care  
Diet planning  
Diagnostic procedures  
Patient education  
and  

Demonstration courses of the computer capabilities as well as service courses involving calculations, conversions, diet analysis and diagnosis.

CAI operates in close conjunction with the Ohio State University Pilot Medical School and with the Division of Computing Services for Medical Education and Research. The Pilot Medical School is an experimental program in physician education which relies heavily on computer based management of instruction. This methodology employs the computer to monitor and guide student flow through the curriculum, to report student progress, to provide utilization information and item statistics reports on individual course items, to schedule learning activities and resources and to maintain a permanent data base.

The Division of Computing Services is involved in supporting and developing instructional uses of computers and in assisting personnel to utilize the computer's capability for research projects and for information storage and retrieval. Currently, the Division is staffed by a Director,
a systems analyst, a systems analyst-systems programmer, a hardware systems analyst and a programmer.

At present the computing needs of the division are met by an IBM 360/50 computer running under the control of the IBM Operating System OS. Approximately thirty remote terminal locations are supported twenty-three hours a day via an 82K partition dedicated to a CAI teleprocessing package. The software system for the on-line CAI systems is described below:

The COURSEWRITER III, OS Version 2 operates in a multi­programming and teleprocessing environment under the control of Operating System/360 (OS/360) and using the BTAM, BSAM and BDAM access methods. Several OSU College of Medicine developments, i.e., functions and subroutines have been incorporated into the basic IBM COURSEWRITER III, Version 2 system. COURSEWRITER III, Version 2, as released by IBM, is a subset of the OSU Health Center and modified COURSEWRITER III, Version 2 programs. The subroutines and functions which have been developed are written in assembler language. They are non-resident, 2-K maximum and are serially reenterable. *See the complete list below for these programs.

In addition, background programs have been developed by the OSU College of Medicine to generate reports from system produced records. Data is stored on disk, and information on this system can be obtained from personnel...
of the OSU College of Medicine's Division of Computing Services.

*LIST OF CAI SUBROUTINES WRITTEN AT OSU*

* fn stdata: gives the course author access to special student information (student name, date, etc.)
  * fn fstnam: allows the author to say "Type your name", from which this function will select the first name only
  * fn rmp: permits the system to keep track of multiple users within a single sign-on number
  * fn pms: handles student management for the Pilot Medical School
  * fn set: gives the author extensive mathematical capabilities
  * fn string: permits concatenation and manipulation of data strings
  * fn record: allows the author to record a message to himself on the Student Recording Tape
  * "calc" is made up of subroutines but operates like "help" (that is transparent to the program); it gives the student access to the computational ability of the computer.
  * "define" is constructed like "calc" and "help"; it gives the student access to an on-line medical dictionary.

Software systems and programs other than the IBM COURSEWRITER package, are designed and developed by Division personnel where needed.
1. Tutorial Dialogue

One of the most extensively developed CAI techniques is the tutorial dialogue between a student and the computer. This technique is characterized by (1) the presentation of learning material to the student in various step sizes, (2) a question or test item, and (3) evaluation of the student's response, reinforcement, and/or branching to another section of the instructional program. Essentially, there are two basic formats in which the tutorial technique is presently being used in CAI lesson design. The first consists of a "complete" tutorial dialogue between the student and the computer. This is to imply that all information, concepts, and learning materials are presented to students via the CAI terminal; and no "off-line" methods are used. Except in the lower elementary grades, this amounts to a tremendous quantity of material flowing through the computer; and, if

exaggerated, the computer has a tendency to develop into an expensive page-turner.

The second type of tutorial lesson is referred to as a "partial" tutorial dialogue. The student's initial exposure to the material to be learned is from an off-line source, such as a traditional lecture, ETV, or reading material. The material may initially be presented to the student in a more rapid, condensed form, which is limited to one-way communication. The student would next be exposed to diagnostic testing routines via CAI, which would test his attainment of each concept presented via the initial source and branch him to two-way tutorial routines as previously described.

2. Drill and Practice

A second basic CAI techniques is the utilization of remote terminals for what otherwise might be long and tedious drill and practice exercises of concepts to which students have been previously exposed. To date, this technique has been most usefully exploited at the elementary school levels via remote teletype or typewriter terminals. The instructional strategies are usually quite simple, as the computer is used to provide practice in particular concepts, and diagnose the child's weaknesses. At the end of each day, the computer can indicate to the teacher which pupils need help, and their specific areas of difficulty.
There are basically two types of drill and practice exercises. The first consists of practice problems and routines that are designed by the course author, generated by the instructional program, and presented to the student via the computer terminal.

The second type of drill and practice exercise is substantially different as the student is allowed to generate his own problem set. Such an exercise provides the student with the opportunity to construct his own problem set and input data and to respond with his solution to the practice problem. The computer calculates the correct answer and compares it to the student's response. The instructional program may branch the student to particular additional problems or suggest the student construct a particular kind of problem or one of increased difficulty.

3. Simulation

Computer simulation of laboratory exercises and other real world situations represents a third significant CAI technique. In this situation a mathematical model is generated which simulates the real life occurrence of a particular environment and allows the student to interact with the model. This technique can provide learning experiences to students that might not otherwise be available because of factors such as safety, equipment cost or availability, prohibitive set-up time, or other factors of cost or
convenience. The simulation of high school laboratory exercises can take different forms. There are a number of experiments which are desirable to perform in high school if sufficient equipment or time is available; these experiments may be simulated by the construction of mathematical models for exposure to all students or used as enrichment for more advanced students. Another utilization of simulated laboratory experiments is for practice of particular science concepts after a laboratory experiment has been performed. A simulation can also be a group classroom demonstration which is integrated into the traditional instructional setting.

4. Problem Solving

Problem solution involves the utilization of remote computer terminals to perform calculations of various complex formulas or expressions; this reduces the time students devote to routine calculations. The calculational power of the computer is brought into the classroom in an effort to introduce more complex learning materials.

There are two fundamental modes in which remote terminals can be utilized for problem solving. First, the instructor in a traditional classroom or laboratory situation can use the terminal to "demonstrate" the result of changing various parameters of a complex equation. In such a situation only the instructor or a small number of the
students actually interacts with the terminal, but its results are used to support concepts presented in class.
APPENDIX D

COMPUTER ASSISTED INSTRUCTION
IN INDEPENDENT STUDY
CAI as a tool for facilitating the independent study concept at the curriculum level in the teaching of basic science concepts to medical students.

The Ohio State University Pilot Medical School is a research project investigating the effectiveness and efficiency of utilizing selected concepts of independent study in medical education. The charge which confronted the Pilot Medical School (PMS) was to design, implement and evaluate a preclerkship curriculum that would incorporate as its foundation, certain educational principles and tenets of independent study. The PMS was formed as a result of a three-year grant from the U.S. Public Health Service, Division of Physician Manpower. The grant provided for one year of program development followed by two years of operation and evaluation. The period of the grant is from June, 1969 through June, 1972, and the first class of thirty-two students began their medical studies under this independent study curriculum in July of 1970. The second class of 59 students began in July of 1971 and a third class of approxi-
mately 60 students will begin in July of 1972. It should be noted that the 1972 class of students will be supported on the College Budget. The "regular" Ohio State Medical curriculum is a four-phase, three-year (35 months) curriculum; and the PMS is comparable to the first three phases (15 months) of that curriculum. The total medical school enrollment is approximately 216 students, per class.

The concept of independent study means different things to different people, it encompasses a spectrum of individual interpretation and operational structure. PMS does not employ Computer-Assisted Instruction (CAI) in a primary instructional role. The student's use of the computer is for tutorial self-evaluation, hence, the self-evaluation exercises were designed to provide the student an opportunity to gauge his progress and determine his success in satisfying the objectives of the unit.

A tutorial self-evaluation program is available for each instructional unit (submodule). These exercises were designed by the faculty to test comprehension of the instructional objectives for each submodule. Items in the exercise may be constructed response, true-false, multiple choice, matching or ranking questions. The computer encounters the student with a question and then immediately evaluates his response. Correct answers receive a reinforcing type of feedback, while wrong answers triggers corrective feedback and another chance to respond to the
question. The computer will also respond to unanticipated answers and attempt to coach the student, through a series of statements, to the correct answer.

Of particular note are the different types of computer feedback provided by the author for the student's answers. The computer programs have also been designed to indicate to a student when he is not doing well on the TES. In this instance, the computer will alert him to his deficiencies with study prescriptions. Study prescriptions may appear as an additional study assignment, a review of previously suggested material, or a simple statement suggesting a faculty conference.

Several conditions were necessary for the PMS concept to even be considered, these conditions still hold true today:

1. The OSU COM has a stable system running on an IBM 360/50 which is operational 22 hours per day. The computer support personnel for CAI have the experience and expertise necessary to handle CAI hardware and software problems, and to modify the COURSEWRITER package to accommodate user needs.

2. There is sufficient expertise in strategies, design and usage within the Division of Medical Education to properly utilize CAI. Expertise also exists in authoring techniques, instructional programming, and the use of audio-visual materials along with CAI.

Given the efforts described above, proposals for further CAI developments have been submitted as follows:
1. To link the OSU COM CAI system to the National Library of Medicine MEDLINE Communications network.

2. To extend the PMS independent study concept to the clinical years of medical school.

3. To package and prepare PMS materials for easy distribution to other medical schools and potential users.
A PILOT PROGRAM OF INDEPENDENT STUDY IN MEDICAL EDUCATION

The Ohio State University
College of Medicine

JAMES V. GRIESEN, M.B.A.
ROBERT L. BERAN, Ph.D.
ROBERT L. FOLK, M.D.
JOHN A. PRIOR, M.D.

A Paper Presented at

The 5th Rochester Conference on Self-Instruction in Medical Education
April 1-3, 1971

The Program described in this paper is being supported in part through the National Institutes of Health research grant number 5 R01 PM 00040 from the Division of Physician and Health Professions Education, Bureau of Health Manpower Education.
TUTORIAL EVALUATION SYSTEM (TES)\textsuperscript{1}

The PMS does not employ Computer-Assisted Instruction (CAI) in a primary instructional role. The student's use of the computer is for tutorial self-evaluation, hence, we call the system TES, for Tutorial Evaluation System. The self-evaluation exercises were designed to provide the student an opportunity to gauge his progress and determine his success in satisfying the objectives of the unit.

A TES program is available for each instructional unit (submodule). These exercises were designed by the faculty to test comprehension of the instructional objectives for each submodule. Items in the exercise may be constructed response, true-false, multiple choice, matching or ranking questions. The computer encounters the student with a question and then immediately evaluates his response. Correct answers receive a reinforcing type of feedback, while wrong answers trigger corrective feedback and another chance to respond to the question. The computer will also respond to unanticipated answers and attempt to coach the student,

\textsuperscript{1}This abstraction and reprint was made with the permission of the major author.
through a series of statements, to the correct answer. Figure 3 illustrates a sample TES constructed response item. The left portion of the figure indicates the student-computer dialogue with a brief explanation of the exchange noted on the right. Take particular note of the different types of computer feedback provided by the author for the student's answers. The computer programs have also been designed to indicate to a student when he is not doing well on the TES. In this instance, the computer will alert him to his deficiencies with study prescriptions. Study prescriptions may appear as an additional study assignment, a review of previously suggested material, or a simple statement suggesting a faculty conference. At the completion of his TES exercise, the student keeps the computer print-out for study, reference, or review.

**MOST DESIRABLE FEATURES OF THE PILOT MEDICAL SCHOOL**

Summarizing in January their feelings regarding the PMS, the students generally indicated that the most desirable features of the PMS had to do with the benefits of independent study. They expressed great satisfaction at being able to progress at their own rate, set their own schedule, and pursue interests in various fields. They also expressed considerable satisfaction with the faculty of the PMS and the relationships which they have formed with the students.
FIGURE 3

TES EXAMPLE

(Left portion)

STUDENT-COMPUTER DIALOGUE

1. Dial Slide 46. This slide shows a diagram of a frontal section exposing the anterior surface of pituitary gland. If you know the indicated structure you will know one way an expanding mass of the pituitary may present clinically.

If the mass extends upward and impinges on the structure numbered 1, the patient will present with what clinical sign?

blindness

You are nearly correct. Indeed, there will be visual loss, but it is the optic chiasm that is affected and hence, a specific type of visual loss occurs. Try to be more specific.

hemianopsia

Hemianopsia is too general. It could refer to field losses of various types in one or both eyes. Try again.

binasal

Incorrect. The fibers that cross in the optic chiasm come from the nasal one-half of the retina, but this would not cause a nasal field loss. Try again.

bilateral

I will accept this, as I assume you mean bitemporal hemianopsia. This is, of course, caused by loss of the crossing fibers from the nasal parts of the retina.
(Right portion)

-The computer provides introduction and requests student to examine slide

-The computer asks a question

-The student responds

-The computer responds with coaching and tutorial feedback

-The student responds (incorrect answer)

-The computer provides corrective feedback

-The student responds (incorrect answer)

-The computer responds with corrective feedback and coaching toward correct answer

-The student responds (correct answer)

-The student is provided with reinforcement
LEAST DESIRABLE FEATURES OF THE PILOT MEDICAL SCHOOL

As was the case with the positive features enumerated by the students, the negative features identified were varied in nature and wide in scope. Unlike the desirable features, however, there were far fewer undesirable features which were enumerated by more than one student. Negative aspects of the PMS which appeared with any significant frequency dealt largely with (1) the need for better instructional objectives (more detailed), and (2) the need for more quiet places where students may study. It was almost amusing to note that one student complained that the scheduled physical diagnosis sessions (two hours per week) break up his study schedule too much, and that another student complained that the schedule of seminars and special meetings (about one hour per week) becomes intrusive.

DOES THE TUTORIAL EVALUATION SYSTEM WORK?

In an effort to answer this question we posed two related questions to the students of the PMS. These questions and the summary of student responses are indicated in Table 11. While some students have changed their perception of the TES exercises to some extent, it would appear on the whole that the exercises are highly valued by the students.
TABLE 11
Responses of 31 PMS Students to Two Questions Concerning the Value of the Tutorial System (TES)

"DO YOU FEEL THAT THE TES EXERCISES ARE:"

<table>
<thead>
<tr>
<th>RESPONSE CATEGORIES</th>
<th>NUMBER OF STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERY HELPFUL</td>
<td>11</td>
</tr>
<tr>
<td>HELPFUL</td>
<td>16</td>
</tr>
<tr>
<td>ADEQUATE</td>
<td>3</td>
</tr>
<tr>
<td>NOT VERY HELPFUL</td>
<td>--</td>
</tr>
<tr>
<td>NOT AT ALL HELPFUL</td>
<td>--</td>
</tr>
</tbody>
</table>

"HAS YOUR PERCEPTION OF THE TES EXERCISES CHANGED, WITH REGARD TO HOW HELPFUL THEY ARE AS A MEDIUM OF SELF-EVALUATION?"

<table>
<thead>
<tr>
<th>RESPONSE CATEGORIES</th>
<th>NUMBER OF STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO CHANGE FROM BEGINNING</td>
<td>7</td>
</tr>
<tr>
<td>RELY MORE ON TES THAN BEFORE</td>
<td>10</td>
</tr>
<tr>
<td>RELY LESS ON TES THAN BEFORE</td>
<td>14</td>
</tr>
</tbody>
</table>
SUMMARY

The independent study curriculum of the Pilot Medical School at The Ohio State University has been in operation for over eight months. It has proven that such a program is feasible from an operational standpoint, and it is anticipated that a detailed cost analysis will prove it to be economically feasible as well. The students have generally reacted with great enthusiasm for the freedom and flexibility which the curriculum provides, giving them a chance to study and learn in accordance with their individual differences. The introduction of physical diagnosis and other clinical material into the early phases of the curriculum has improved student motivation and given greater relevancy to much of the basic science material. The interdisciplinary mix of clinical and basic science faculty members has proven to be a most healthy environment in which teaching and learning occur freely. The computer-based Tutorial Evaluation System provides individualized evaluation exercises for each student, and these exercises provide the faculty with valuable diagnostic and performance data regarding individual student progress. Development and evaluation of the PMS curriculum will continue through May of 1972. During the 1971-72 grant year, considerable attention will be given to revising the curriculum materials and packaging them for dissemination to other medical schools.
who would be interested in adopting all or part of such a curriculum.
APPENDIX E

PARTICIPANT INSTRUCTIONS:

RESEARCH STUDY
Thanks for your help in this research study and tryout phase.

You should have received:

________ set of slides (see contents)

________ set of SLATs (""

________ set of DITs (""

_________ PIB

_________ packets with response sheets, opinionnaire and instructions

_________ Introduction (TCS) tape

Please return the slides and cassettes along with all completed original response sheets and opinionnaires as soon after the 2 week period as possible. If a time extension is needed in order to circulate the slides and tapes, please inform me so I can re-schedule distribution.

The participants may keep the PIB and criterion questions to give meaning to their duplicate response sheets.

Now for the research variable: THE TAPE--INTRODUCTION: TCS. DO NOT CIRCULATE IT TO ALL PARTICIPANTS--ONLY those 215
whose study number has been circled should receive this tape. The participants with circled numbers should hear this tape following completion of the entry criterion and prior to SLAT 1.0. The method and circulation of the materials is at your discretion. However, if any of the other participants are curious regarding the introduction tape, there is no reason they can’t hear it following completion of the CRITERION 2. It contains an overview of "why statistics for quality control".

If you feel QUCOST is worthy of additional usage, I am quite sure arrangements might be made to make the slides, tapes and additional PIBs available at a nominal cost. What else can I say, but THANKS.

Jeanne
PARTICIPANT INSTRUCTIONS

This multimedia individualized program is being developed as a dissertation project. Dissertation projects require research study and evaluation. Therefore, your continued participation in this project is needed to produce data to determine the effectiveness of QUCOST as a learning activity -- NOT A TEST! The entire program as well as the entry and terminal criterion should be considered as a study guide through the various segments of statistics for QC.

The purpose of this study does require that some method be employed by which all responses can be identified and correlated. I have randomly assigned numbers to all participants. These numbers must be utilized on all response forms, opinionnaire and as entry to the CAI program. Like most things in life today, you are now another number.

As I mentioned earlier, the main focus of interest is data for evaluation of the program and in estimating its effectiveness as material for independent individualized study. I am primarily interested in four variables: 1) gain in objective achievement; 2) the appropriateness of the materials for learning; 3) your personal comments on
several facets of the program and 4) a time estimate of your involvement in each segment.

Now since this is a research study, I must ask your further cooperation in regards to specific instructions. Some of the rules have been generated as control variables for the study. Other rules pertain to the media utilized for the learning outcome tutorial evaluation segments (LOTES) -- Computer-assisted instruction -- CAI or programmed (scrambled) instruction booklet (PIB).

Your participation is sincerely appreciated. However, I hope your involvement in the project will be as much, if not more, benefit to you than it is to the study.

PIB

1.0 Regardless of practical independent individualized study methods:

1.1 DO NOT consult outside resource material -- use ONLY the tapes, slides and tutorial evaluation materials provided. You may use any data for practice and take all the notes required -- in fact you should.

1.2 Progression through the booklet is controlled according to your responses. Please adhere to this sequence. You may go back to previously covered material or to the developmental tapes (DIT) for
any review necessary....BUT DO NOT read ahead or attempt to cover any material not presented as part of your response path through the booklet.

1.2.1. View only the slide referred to for a particular situation. However once a slide has been identified and discussed, then it may be used for review. This stipulation refers to SLIDES 1-28.

1.2.2. The other slides and the dictionary are to be used through the eight segments as your need dictates. DO NOT REFER TO THE DIT OR DICTIONARY WHILE TAKING THE ENTRY OR TERMINAL CRITERION TESTS.

1.3 Take all segments -- SLATs and LOTESs -- unless allowed to choose.

1.4 You may utilize any or all of the DIT material. However, you are not required to do so.

1.5 Once you have completed the terminal criterion C-2, you may of course pursue any material within or without the program.

1.6 This project has a time limit. In order to evaluate the material, as is, I must ask you to complete the program within a TWO-WEEK PERIOD. You may start and stop within the program as your time dictates. The time for completion depends on your previous knowledge. I estimate the minimum in-
volvement to be appx. 6 hours -- including SLAT and LOTES.

2.0 Please read the "Preface" and "Instructions for the Learner" in the front of the PIB before starting with the entry criterion.

3.0 For the purpose of the study, I need the original record of your responses. I have provided duplicate response sheets and carbon for all responses -- criterion and LOTES. Return the original. You may keep the duplicate for your records.

2.1 Once you have recorded your response and proceeded to the answer or next question, DO NOT GO BACK and change your response on the original. Make any notations you need to at the side or on the duplicate. Fill in all blanks as required -- according to your sequence of learning. There are multi-blanks when indicated in the question. Multi-blanks DO NOT appear on the response sheets for all questions with multi-answers. This implies that some questions may require more than one word or letter to be acceptably correct.

I also need an estimate of your time involved with the: SLAT, LOTES AND DIT OR PRACTICE. Please record these as requested on the sheets. Just
remember to make a notation of the time when you
started and stopped -- each time. I'll make the
conversion and total same.

5.0 Please complete and return the Opinionnaire. Since
this is the tryout phase, any and all comments are
welcome.

6.0 Make sure your number appears on all sheets re­
turned.

7.0 Return all original response sheets. You may keep
the PIB -- just a small measure of my thanks -- if
you so perceive -- for your participation. I hope
QUCOST is of benefit worthy of your time.

Jeanne

CAI

1.0 Regardless of practical independent individualized
study methods:

1.1 DO NOT consult outside resource material -- use
ONLY the tapes, slides and tutorial evaluation
materials provided. You may use any data for
practice and take all the notes required -- in
fact you should.

1.2 View only the slide referred to for a particular situation. However, once a slide has been identified and discussed, then it may be used for review. This stipulation refers to SLIDES 1-28.

1.3 The other slides and the dictionary are to be used through the EIGHT SEGMENTS as your need dictates. DO NOT REFER TO THE DIT OR DICTIONARY WHILE TAKING THE ENTRY OR TERMINAL CRITERION TESTS.

1.4 Take all segments -- SLATs and LOTESs -- unless allowed to choose.

1.5 You may utilize any or all of the DIT material. However, you are not required to do so.

1.6 This project has a time limit. In order to evaluate the material, as is, I must ask you to complete the program within a TWO-WEEK PERIOD. You may start and stop within the program as your time dictates. The time for completion depends on your previous knowledge. I estimate the minimum involvement to be appx. 6 hours -- including SLAT AND LOTES.

2.0 Some questions may require more than one word or letter to be acceptably correct.

3.0 Please keep track of the off line time spent on: SLAT, DIT and practice. Your estimation will be
requested at the end of the program. Keep separate
time for each section -- 1.0, 2.0, etc. The com-
puter records time on terminal.

4.0 Please complete and return the Opinionnaire to the
person coordinating the study at your institution.

6.0 Make sure your number appears on all sheets returned
-- the same number used to take QUCOST on CAI.

Thank you for your time and cooperation. I hope QUCOST has
been a benefit worthy of your time.

Jeanne
APPENDIX F

TERMINAL CONTEXT SUMMARY
Hi! Welcome to QUCOST - Statistics for Quality Control (QC). This program is to be a learning experience individualized to your needs. The amount of practice and review included in the total program is your prerogative.

But why, you ask, are the learning outcomes of QUCOST necessary?

QC is many things to many people. Primarily its function is to keep variability within bounds. In other words QC is a method that determines the degree of variability associated with a particular activity or procedure.

General Diagnostics contends that "every analytical laboratory should have some system for testing the quality of its work. But the clinical laboratory is in a special situation. Its work is used in making medical judgements about human beings; invalid results can have extremely serious effects. The problems of the clinical laboratory are compounded by the need for speed. The patient is changing and (often) so is the patient sample. The clinician needs his answers "now" and they must be valid the first time. Or, if they are wrong, the analyst must know it, so that an invalid result is not reported to the clinician."
The need for accuracy notwithstanding, a simple rapid procedure which yields clinically acceptable results may sometimes be preferable in the clinical laboratory to a method which is more precise and accurate, but more complex and time-consuming. Where such a compromise has been made, quality control is especially important, since without a knowledge of the variation inherent in the procedure -- which may in some instances be considerable -- the clinician cannot properly distinguish between normal and abnormal values.*'

In QUCOST, we are interested in QC as a statistical system for measuring the reproducibility or degree of precision in procedures.

You say, "QUCOST is not for you." You are not in medical technology. QC is of no interest to you. Well, as for the last, accountability has arrived on the scene. One part of accountability is the evaluation of how well a professional is doing his job. According to Deterline, "most of us are held accountable for our work. We are expected to earn our salaries by producing results, by carrying out the tasks assigned to us with at least a minimum acceptable level of competence." If an individual or system is to be held accountable there must be established goals, exact specifications of what is to be accomplished by each component in the system, techniques and activities to see that each specification is achieved. Meeting specifications is
QC; seeing to it that specifications and QC work is accountability.

QUCOST is not expected to produce experts in QC. The subject is too broad for that. The concepts of QC presented here are done so only to put statistics in reality. The focus of the material is on an introduction to the basic statistical tools utilized in determining the so-called average and fluctuation around that average. Sure a lot of the data and examples are those found in the clinical laboratory, but -- if you have ever looked in statistic books, you will note that the majority of the data is that of educational or psychological testing and research. I think that it is about time that medical technology gets the chance to be an example. OK? ? ? Just consider the data as numbers. What area of interest they come from is of less importance. What is of importance is the type of data, the use you make of it and how you interpret the results.

The methods of statistics are the tools of QC. A common-sense approach to QC in the clinical laboratory calls for only a small amount of statistical knowledge. All that is needed is an appreciation of some of the basic statistical methods and ideas. I know from experience that when confronted with an in-depth presentation on statistics, one tends to withdraw from active participation in learning experiences with statistics. How about you? ? ? ? ?

QUCOST is based on a detailing of tasks involved in
producing QC charts. The entire procedure cannot be done by automation. Human input and interpretation of output are, in reality, part of the program. The learning outcomes are the products of conversion — tasks to general learning outcomes. Through experience, enabling statements were added to suggest learning activities that might lead to achievement of these outcomes.

WHY QC CHARTS? QC charts are a graphic means of detecting systematic variation from the quality to be expected in repetitive measurements — that is variation greater or less than the random fluctuation which is inevitable and allowable. The charts may be used as a simple method of performing statistical tests of the hypothesis that subsequently produced results have essentially the same quality as those previously produced. QC charts relate to a process in action and, by on site inspection, indicate when a procedure should be examined for trouble.

A separate control chart should be used for each procedure. For instance, in the clinical laboratory, separate charts would be used for glucose, chlorides, sodium, potassium, CO₂, pH, pCO₂, Hb, Hct. etc.

The technique of constructing QC charts is to set up, in graphic form, limits for a sample statistic on the basis of approximately 15-30 preliminary samples from the control to be utilized. A new chart is required whenever there is a major change in the variables of the procedure.
If the preliminary run yields a result outside the computed control limits, the procedure was not initially under control and should be stabilized before the control chart is set up.

The sample values should cluster about a central line. The upper and lower limits are usually set up symmetrically at \( \pm \) the calculated deviation of allowable limits. If the accepted limits were \( \pm 3s \), then as long as the procedure remains satisfactory, the probability that a value outside these confidence limits will occur in less than 0.3%.

Therefore, if during runs that follow, a result should be obtained and recorded outside the limits on its control chart, it would be considered chance or a change in the process. In any event, it should immediately be investigated to determine the cause of the change. You should also remember that a continued trend in one direction, even if within limits, might suggest trouble and the source should be detected and corrected before the procedure is completely out of control. Also results consistently above or below the central line may suggest something at play, even when they do not trend in one direction nor pass the control limit.

OK, now that about covers it. This short presentation was made with the intention of explicating the role of basic statistics in a task from reality -- a day-to-day, hour-to-
hour, minute-to-minute phenomenon in the clinical laboratory. It is not the intent of QUCOST to make you experts in Quality Control. The purpose is to present, in learning activities, the basic statistical tools utilized in systematic QC. Now for the activities that are designed to help you acquire the fundamentals and skills to perform these tasks.
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